Electronics®

Tv that sees better than the human eye: page 78

Measuring stored charge on a diode: page 84

How to design biotelemetry gear: page 89

June 28, 1965
75 cents
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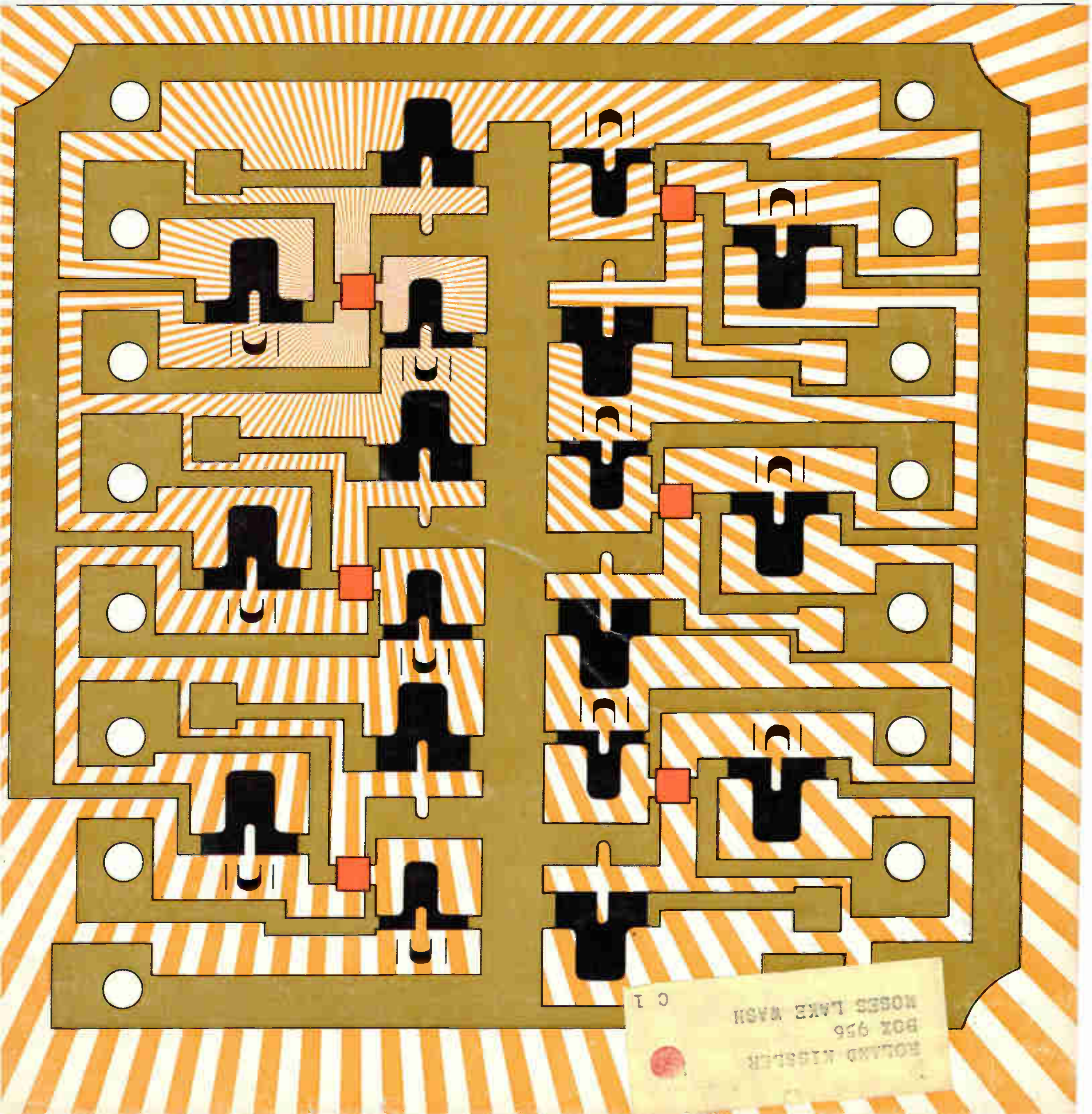
Below: new method makes reliable hybrid integrated circuits, page 66



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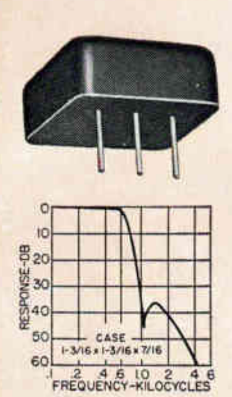
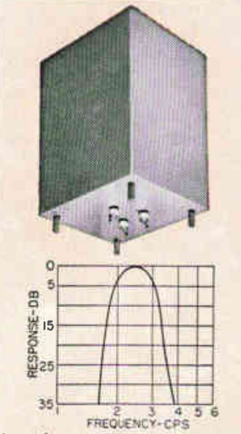
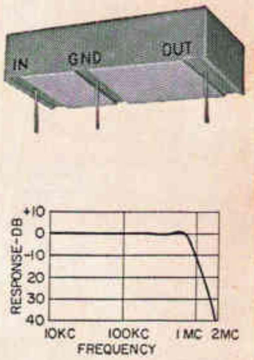


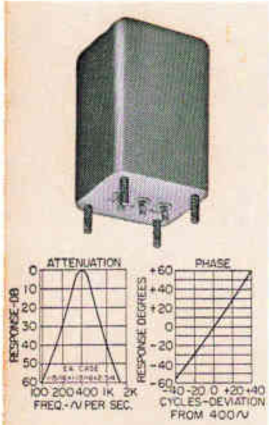
560 — Telemetering low pass filter. Available from 400 — to 70 KC. ± 7.5% bandwidth flat to 1 db. Attenuation greater than 35 db beyond the 2nd harmonic of — 7.5% frequency. Impedance 47K ohms. MIL-F-18327B. Wt. 0.8 oz.



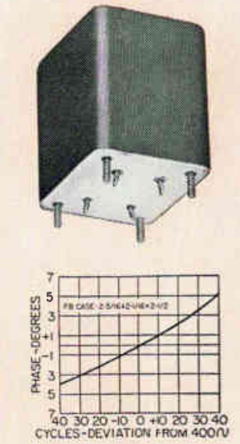
Low frequency band pass filter. Designed for 2.5 cps center frequency. At 2 to 3 cps within 3 db. At 1.5 cps and lower, and 4 cps and higher, greater than 30 db. Source and Load 10K ohms. Size: 4 x 4-11/16 x 6". MA MIL case, MIL-F-18327B.



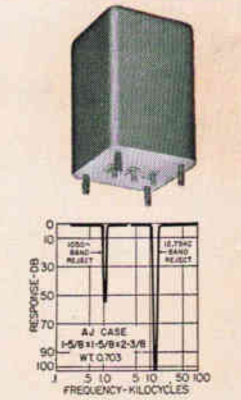
High frequency low pass filter. Zero to 700 KC within 1 db. 1.95 mc to 10 mc 40 db minimum. Source and Load 1000 ohms. Molded flat construction for printed circuit applications. Size: 1 x 2 x ½"; Wt: 1 oz. MIL-F-18327B.



Band pass 400 cycle Gaussian filter. Linear phase response in pass band. Attenuation 380 cps to 420 cps within 0.5 db. 2nd harmonic down 25 db, 3rd harmonic down 45 db. Source and load 5K ohms. MIL-F-18327B Wt., 0.9 lbs.



Minimum phase shift 400 cycle band pass filter. Within ± 1.5 db 370 to 430 cycles, greater than 45 db beyond 1100 cycles. 1K ohms to 100K ohms. MIL-F-18327B; 1 lb.



Band reject filters (two shown). The 1050 ∿ filter has 50 db attenuation and is only 3 db at 950 and 1150 cycles. The 12.75 KC filter has more than 100 db attenuation and is only 3 db at 10.8 and 15 KC. Source and load 600 ohms, both are MIL-F-18327B.

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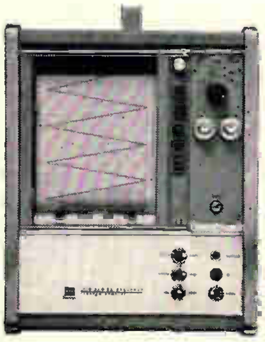
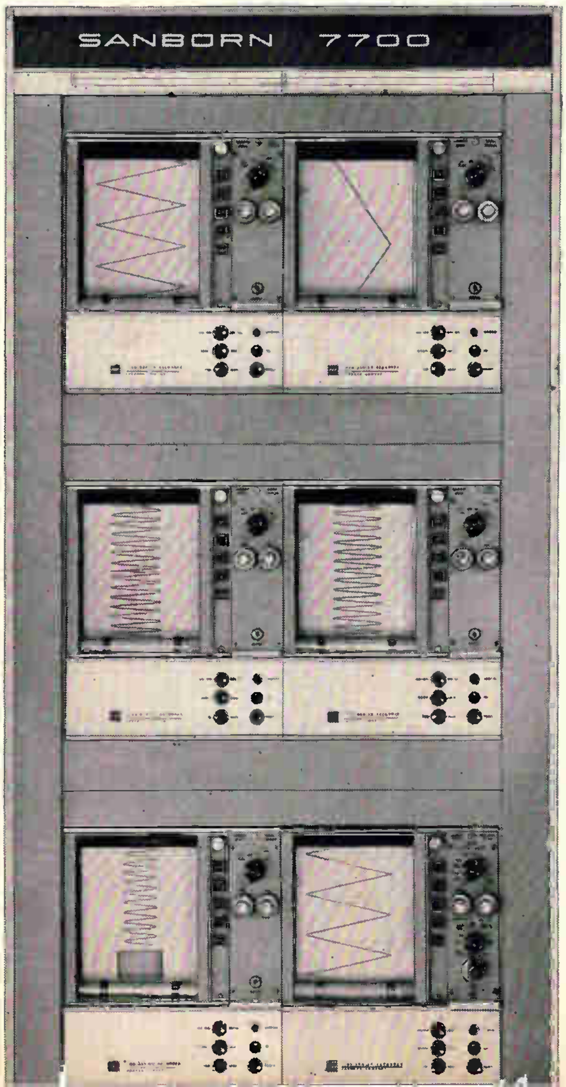
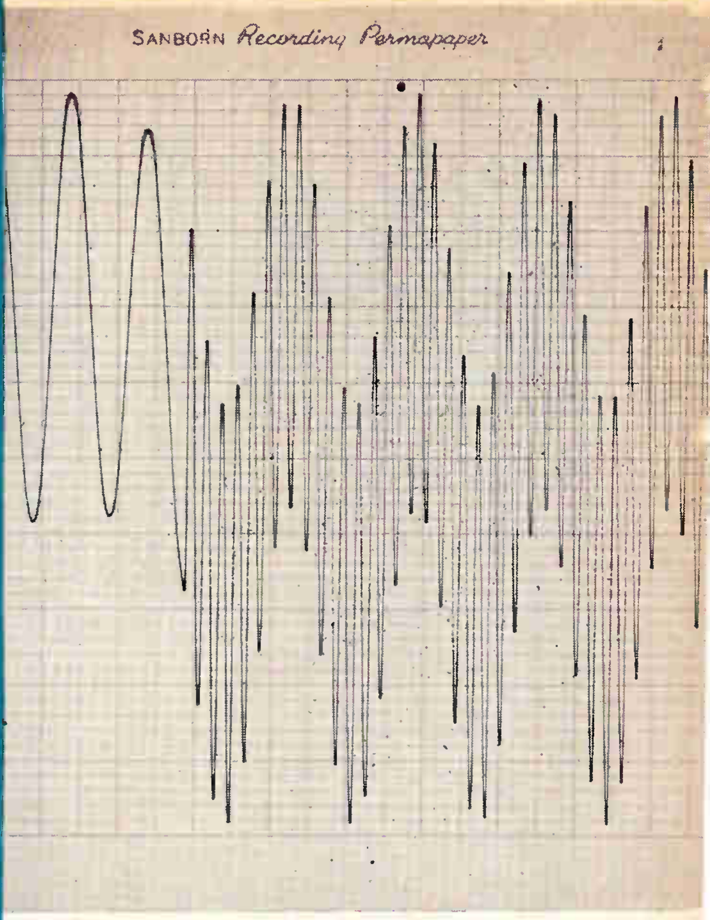


by two . . . four . . . six

(or <u>any</u> number the test calls for)





All the advantages of the Sanborn single-channel 100 mm wide-chart recorder are now immediately applicable to tests requiring measurement of 2, 3, 4, 6 or more parameters.

You see the signal far more clearly on 100 mm wide charts. Amplitude variations representing changes as small as 1 uv can be easily resolved.

You have precise control and wide signal conditioning capabilities with interchangeable plug-in preamplifiers — just plug in the one you need. Four different DC preamplifiers are available with sensitivities of 1 uv/div (to 250 V full scale), 1 mv/div, 5 mv/div and 20 mv/div; all except the last have zero suppression to expand the portion of signal of greatest interest. High-gain type has floating and guarded input. Carrier preamplifier for AC transducer outputs has 10 uv/div sensitivity. Phase-sensitive demodulator preamplifiers measure in-phase or 180° out-of-phase components with respect to a 60 cps to 20 kc reference.

You can record at four chart speeds from 0.5 mm to 50 mm/sec. — or at eight speeds from 0.5 mm/min. to 50 mm/sec. with optional version.

You pay for only as many channels as you need — unused channels are not operating needlessly. Measure similar or unrelated parameters individually or simultaneously. And you still have portability: take one complete channel into the field by removing lightweight, compact recorder from the cabinet and using it in its own carrying case.

System may be ordered with as few as two or as many as eight recorders — from $2925 to $10,050. Call your local H-P Field Engineering Office for complete specifications and application help . . . to put the right instrumentation to work on your measurement/signal conditioning/recording requirements. Or write Sanborn Division of Hewlett-Packard, Waltham, Mass. 02154.

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Electronics

June 28, 1965
Volume 38, Number 13

Electronics Review

Probing the News

Electronics Abroad

Technical articles

I. Manufacturing

II. Design

III. Applications

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Readers Comment

Plain talk

To the Editor:

In the editorial "Plain talk" [June 14, p. 15], your comments strike a familiar note since my own experience during the past year, in attempting to organize a proprietary marketing organization for educational and medical electronics, has been frustrated by the limited vision of both the electronics manufacturer and the potential user.

The manufacturer is generally not responsive to the concept of the systems approach to product marketing that is essential to achieve successful applications and customer satisfaction. It seems that the wholly sales-oriented marketing managers continue to dictate the traditional hardware merchandising attitudes.

Potential users, on the other hand . . . tend to regard suggestions of a change of system including more sophisticated technical aids as an encroachment on their domain. A highly articulate audio-visual director and educator at a local university, with whom I discussed electronic educational aids, stressed the fact that educators will be moved to action in this field only by convincing arguments from "members of the club."

We are slowly entering the era of sophisticated electronic application to civilian enterprise, and in a large measure the inhibiting factor to more progress in this area is the lack of communication facility between the electronic engineer and the ultimate consumer.

It is interesting that electronic data processing has been a notable exception to the foregoing statement. On examination it becomes clear that this phenomenal success is probably due to the emergence of a "software technology" as manifested by systems engineering and the programing sciences.

To bridge the chasm between the electronics manufacturer and the nontechnical consumer it is my contention that a concept of software technology must be universally accepted as a necessary

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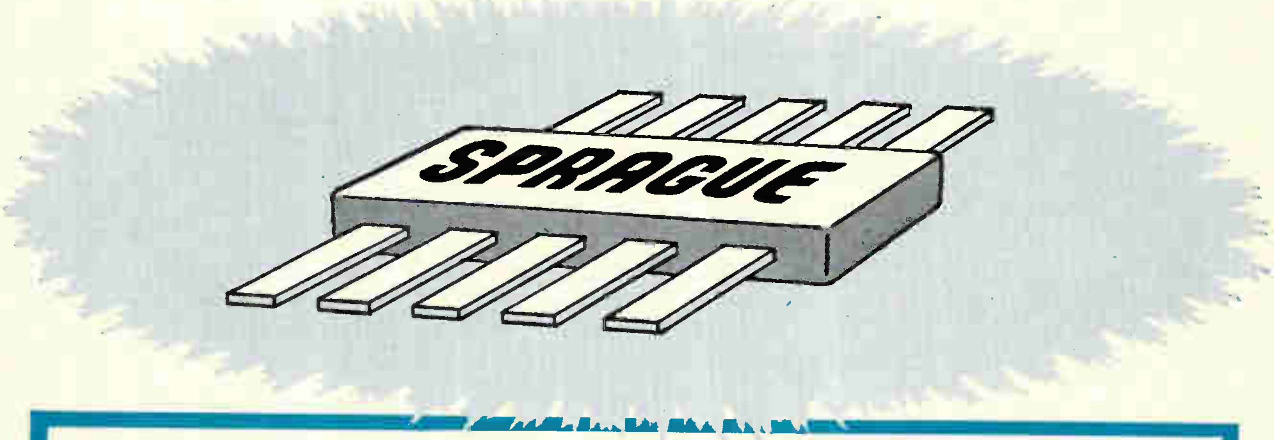

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adjunct to successful hardware applications.

For our critical educational needs, for example, a system analysis by competent and respected professionals would assure a rapid and successful employment of the powerful tools available for enhancing the educational process. Significant experiments have already shown the potential power of this emerging technology.

N. A. Moerman
Roslyn Heights, N. Y.

Reading backwards

To the Editor:

In Mr. Schaffner's excellent article on varactor multipliers (May 17, pp. 56-64) a test setup is illustrated in detail on page 59. The two Bird Thruline wattmeters are connected correctly, but are referred to in reverse in the caption.

The error is an easy one to make, since items are usually identified from left to right, and a higher meter pointer position is naturally assumed to be the higher reading. Bird Thrulines, however, are multi-range directional wattmeters, indicating the power flowing in the direction of the arrow stamped on the round plug-in elements.

In your picture, (below) the right Bird Thruline with the embossed label "PI 12W" uses a 50-watt element and correctly indicates Power In 12W on the 50 watt center scale.

The left Bird Thruline with the label "PO7W" uses a 25-watt element and also correctly indicates Power Out 7W on the 25 watt upper scale.

H. H. Heller
Senior Staff Engineer,
Bird Electronics Corp.
Cleveland, Ohio.

Use for the laser

To the Editor:

While experimenting with some photographic high-resolution tests with a General Electric Co. narrow-spectrum H-4 type mercury lamp as an illumination source, I noted that ordinary white enamel looked like a translucent plastic binder with scintillating pigment crystal particles in solid suspension. Such an observation was not noted under normal wideband illumination conditions.

A gas-type coherent laser beam operating near the ultraviolet end of the light spectrum might present some interesting high-resolution test possibilities with regard to the following items:

- Optical analysis of colloidal solutions, including microscopic dark-field checks.
- Visual inspection of cathode-ray oscilliscope phosphor screens and developed photographic-film grain.
- High-frequency vibrating plate analysis via slant-reflected beams.
- Crystallography axis, strain and transducer vibration analysis.

Ted Powell
Bethpage, N. Y.

3-c to 1.5-Mc Frequency Meter and Discriminator for only $565 in U.S.A.

If 0.2% accuracy is adequate for your frequency-measuring needs, you will benefit in several ways by using this handy little instrument instead of a more costly counter. The dollar saving alone, of course, is substantial. And, if you want a permanent record of frequency drift or change, just connect a recorder to the instrument's output terminals and you have your data. As a bonus, you have an instrument that is also a highly linear, low-noise, pulse-count discriminator for incidental-fm or fm-deviation measurements. With a wave analyzer, you can measure individual components of incidental fm.

The usable frequency range, particularly for frequency-drift and incidental-fm measurements, can be extended upwards to thousands of megacycles per second if the unknown frequency is heterodyned against a stable frequency. This gives a proportionate increase in resolution. At 100 Mc/s, frequency drift and incidental fm can be measured to at least one part in 10^9.

The reason you get 0.2% accuracy in an instrument with a meter is because the first one or two digits of a measurement are transferred to a calibrated switch while the meter interpolates to establish the last two significant figures. Thus, the meter scale is effectively expanded by a factor of 10. When measuring 125.6 kc/s, for instance, the INTERPOLATION OFFSET FREQUENCY switch is set to 1.2 and the meter indicates .56, the last two significant figures.

Measure to 15 Mc/s With Our New Scaler

Connect GR's new Type 1156-A Decade Scaler to the Type 1142-A Frequency Meter and Discriminator and you can measure directly to 15 Mc/s. This scaler is a completely self-contained 10:1 divider of any input frequency up to 100 Mc/s. A five-position input attenuator provides sensitivities of 0.1, 0.2, 0.5, and 1 volt, peak to peak, at 50 ohms; and 1 volt, peak to peak, at 500 ohms. Output is a 20-mA square wave that delivers 1 volt into a 50-ohm load, sufficient to operate most counters without amplification. Height of the instrument is only 1¾ inches. Price is $490.

SPECIFICATIONS
Type 1142-A Frequency Meter and Discriminator

Frequency Range — 3 c/s to 1.5 Mc/s in five decade ranges.

Input Sensitivity — 20 mV from 20 c/s to 150 kc/s, rising to 200 mV at 3 c/s and 1.5 Mc/s (except for very short pulses). Impedance: 100 kΩ, dropping to a minimum of 5 kΩ above 500 kc/s.

As a Frequency Meter — Logarithmic meter maintains constant accuracy; calibrated interpolator effectively expands meter scale by a factor of 10. Higher frequency measurements can be made by heterodyne techniques.

As a Discriminator — Output is 15V, full scale. Low noise; residual fm is down more than 100 dB.

Accuracy — In the "direct" mode, 1% of reading. In the "interpolate" mode, 0.2% of full scale.

Recorder Outputs — Adjustable from 1-mA to 5-mA; interpolator output for high-Z recorders. Voltage is proportional to frequency deviation.

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Circle 7 on reader service card

People

Relatively, ITT Semiconductors is a midget in the semiconductor field; more than a dozen electronics companies retain a head-and-shoulders sales lead over it. But the company, a division of the International Telephone and Telegraph Corp., has growth plans. It has named a marketing-oriented man, **F. Joseph Van Poppelen Jr.,** as president.

The big push, says the 37-year-old Van Poppelen, will be in integrated circuits, which he considers "one of the strongest dollar-growth areas in the total semiconductor market."

Van Poppelen came to ITT from Signetics Corp., where he was marketing vice president for three years. And before that, he served as sales vice president at Motorola, Inc.'s Semiconductor division.

The new president has a bachelor's degree in administrative (mechanical) engineering.

One of the least-known subsidiaries of Ling-Temco-Vought, Inc., is LTV Electrosystems, Inc., which produces airborne communications equipment. With the appointment recently of British-born **E. Bryan Carne,** 37, as engineering director, the subsidiary is expected to place greater emphasis on companion electronic gear, such as ground data-processing and reconnaissance systems.

Carne has a strong background in computer design. Before joining LTV, he was manager of Melpar, Inc.'s intelligence department, where electrical systems are designed along the lines of the human nervous system.

From 1957 to 1959, Carne, who holds a doctorate in electrical engineering from the University of London, served as chief development engineer at the Univac division of the Sperry Rand Corp.

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Meetings

National Association of Music Merchant's Music Show, EIA, NARDA, NAMM; Conrad Hilton Hotel, Chicago, **June 27-July 1.**

Summer Power Meeting, G-P/IEEE; Detroit, Mich., **June 27-July 2.**

International Colloquium on Applications of Mathematics in the Engineering Sciences, Institut f. Mathematik; Hocschule fur Architektur und Bauwessen, Germany, **June 27-July 4.**

Electromagnetic Compatibility National Symposium, G-EMC/IEEE; Waldorf-Astoria Hotel, New York, **June 28-30.**

Physics of Quantum Electronics Conference, ONR; San Juan, Puerto Rico, **June 28-30.**

Electronic Industries Association Annual Convention, EIA; Conrad Hilton Hotel, Chicago, **June 29-July 1.**

International Data Processing Conference and Business Exposition, DPMA; Benjamin Franklin Hotel and Convention Hall, Philadelphia, **June 29-July 2.**

Microwave Applications of Semiconductors Meeting, IERE-IEE; University College, London, **June 30-July 2.**

Biomedical Engineering Symposium, IEEE, US Naval Hosp.; San Diego, Calif., **July 6-8.**

Technical Communications Conference, CSU; Colorado State Univ. Campus, Fort Collins, Col., **July 6-10.**

Airways Engineering Convention, Airways Engineering Society; Dinkler-Plaza Hotel, Atlanta, **July 7-9.**

Engineers and Scientists Patent Law Concepts Meeting, Polytechnic Institute of Brooklyn and the New York Patent Law Association; Rogers Hall of Polytechnic Institute of Brooklyn, **July 12-14.**

Nuclear and Space Radiation Effects Conference, G-NS; Univ. of Michigan, Ann Arbor, Mich., **July 12-15.**

Chemistry and Metallurgy of Semiconductors, Gordon Research Conferences, Univ. of Rhode Island; Proctor Academy, Andover, New Hampshire, **July 12-16.**

Educational Technology Conference, American Management Association; Americana Hotel, N.Y.C., **July 12-16.**

Nuclear & Space Radiation Effects Annual Conference, G-NS/IEEE; University of Michigan, Ann Arbor, Mich., **July 12-16.**

Flight Control Conference and Engineering Display, SAE; International Hotel, Los Angeles, **July 13-15.**

Instrumentation Science Research Conference, ISA; William Smith College, Geneva, N. Y., **Aug. 2-6.**

American Astronautical Society National Meeting, AAS; Sheraton-Palace Hotel, San Francisco, **Aug. 18-20.**

International Conference on Medical Electronics, Japan Society of Medical Electronics and Biological Engineering; Tokyo, **Aug. 22-27.**

Electronic Circuit Packaging Symposium, EDN; San Francisco Hilton Hotel, San Francisco, **Aug. 23-24.**

Medical Electronics & Biological Engineering International Conference, IEEE, IFMEBE; Tokyo, Japan, **Aug. 23-27.**

Computing Machinery National Meeting, ACM; Sheraton-Cleveland Hotel, Cleveland, **Aug. 24-26.**

Western Electronic Show and Convention (WESCON/65), IEEE, WEMA; Cow Palace, San Francisco, **Aug. 24-27.**

Systems Engineering for Control System Design Symposium, IFAC; Tokyo, **Aug. 25-26.**

Radio-Products Fair, Stuttgarter Ausstellungs-GMBH; Stuttgart's Kellesburg, Germany, **Aug. 27-Sept. 5.**

Call for papers

Annual Technical Meeting, Electron Devices Group of the IEEE; Sheraton-Park Hotel, Washington, D. C., Oct. 20-22. **August 1** is deadline for submitting 200-word abstract to William C. Hittinger, Technical Program Chairman, 1965 Electron Devices Meeting, Bell Telephone Laboratories, Inc., Murray Hill, New Jersey.

International Scientific Radio Union (URSI), National Academy of Sciences, National Research Council; Dartmouth College, Hanover, New Hampshire, Oct. 4-6. **July 9** is deadline for submission of 200-word abstract in duplicate to Professor T. Laaspere, Radiophysics Laboratory, Dartmouth College, Hanover, New Hampshire.

Astrodata's New Astrolock*-loop FM Subcarrier Discriminator

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Within ±0.01% of center frequency for 24-hours after a 5-minute warm-up.

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The Astrodata Model 402-201, all solid-state FM subcarrier discriminator utilizes the new Astrolock phase-frequency detector, crystal-referenced, FET chopper-stabilized VCO, and current mode loop filter, which are proprietary developments of Astrodata, Inc.

This completely new and different type of locked-loop discriminator gives performance exceeding that of both conventional phase-locked-loop and pulse-averaging types of discriminators.

The new crystal-referenced, FET chopper-stabilized VCO provides state-of-the-art performance in stability and linearity, without a temperature controlled oven.

The Astrolock detector, with its composite phase-frequency characteristic, assures positive lock-in at any signal level within the 66 db dynamic range. True locked-loop performance is provided for deviations up to ±40%, with specified linearity. A quadrature detector mode of operation, selected by a switch on the front panel, provides correlation detection for extremely low S/N signals.

The Model 402-201 introduces a new method of tape-speed compensation in which the reference frequency is processed in the frequency domain. As a result, tape speed compensation is perfect at any fixed frequency from lower bandedge to upper bandedge, and is better than 30 db for intelligence frequencies up to a modulation index of 4. Deviations of more than ±3% anywhere in the band can be accommodated. No adjustments are necessary.

With this new Astrodata Tape Speed Compensation system, the over-all stability for a given data channel is that of the data discriminator alone, whereas in a conventional system the over-all stability is the sum of the stabilities of both the data discriminator and the reference discriminator.

A complete line of accessories is available for use with the Model 402-201. Channel Selectors and Low Pass Filters are provided for all standard IRIG and Constant Bandwidth center frequencies up to 300 kc. Six discriminators and one common power supply mount in a rack adapter which occupies a panel space of 7-in. x 19-in.

For complete technical information on Astrodata's unique Astrolock-loop FM Subcarrier discriminator and full line of telemetry components, call your local Astrodata engineering sales representative or write to us directly.

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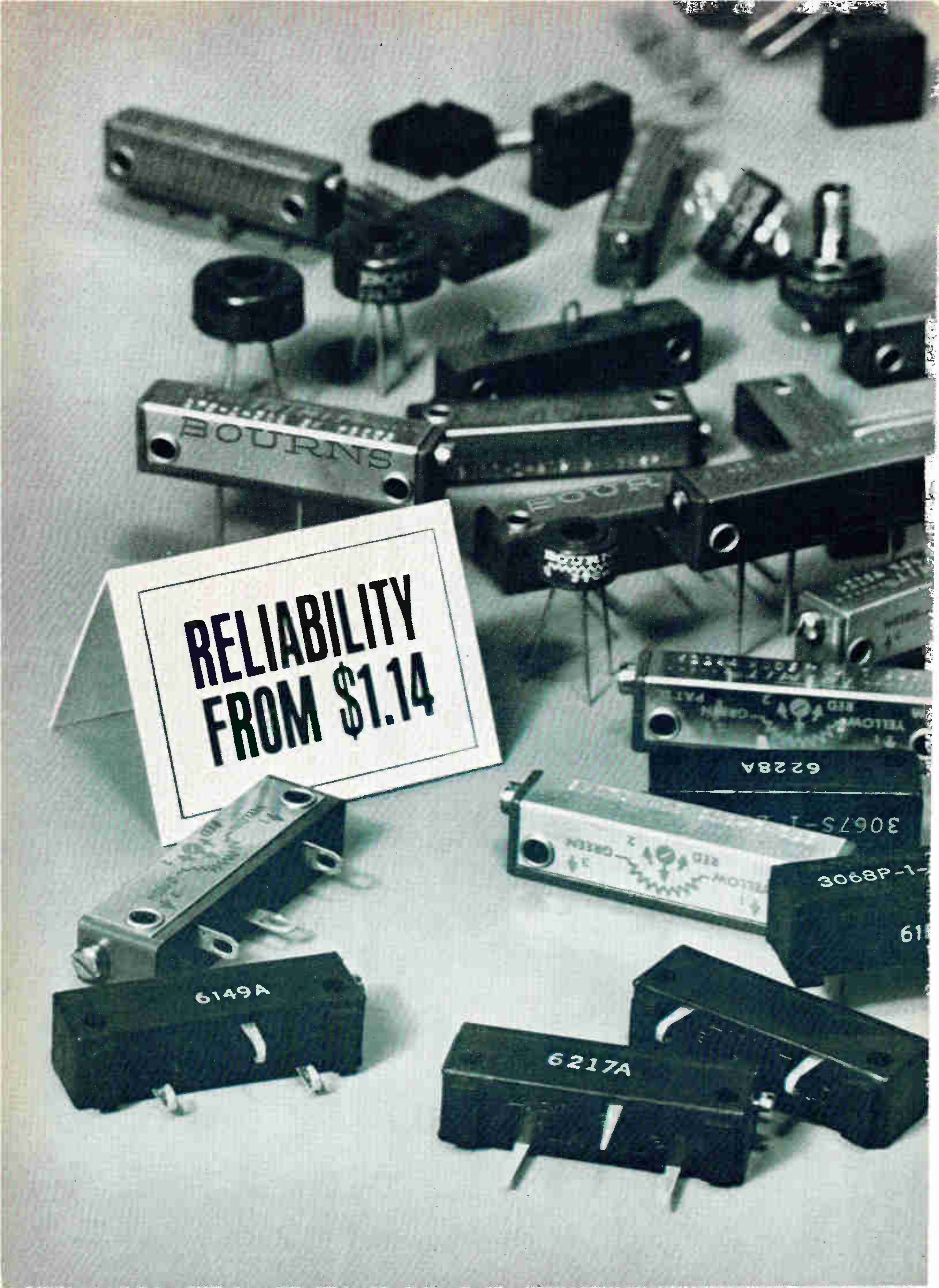
RELIABILITY
FROM $1.14
BOURNS
6149A
6217A
3068P-1-

BOURNS TOTAL VALUE

...the difference between low-cost and cheap

It's understandable if you've never thought of Bourns as a potentiometer bargain basement. You may be surprised to know, though, that Bourns offers you the industry's widest assortment of low-cost adjustment potentiometers.

These are true commercial and industrial units—not downgraded aerospace or military models. *Every* Bourns potentiometer is designed from the ground up for the job it's intended to do.

To be sure, Bourns incorporates many features of its more expensive potentiometers in the low-cost units—many of the same materials, many of the same design improvements and cost-reducing manufacturing techniques. Low-cost models are also subjected to extensive in-process and final inspections, and reliability double-checks. Even the least expensive unit must undergo periodic sampling tests and requalification in the relentless Bourns Reliability Assurance Program.

How, then, can Bourns compete in price? Two reasons: (1) heavy sales volume and (2) an unusual incentive program that motivates every employee to make product quality and production efficiency his *personal concern.*

That $1.14* you pay for a Bourns Model 3067 buys you more than a potentiometer—it buys you reliability. That's *total* value—the reason that Bourns potentiometers outsell all the rest.

*500-piece price

THIS IS BOURNS TOTAL VALUE / Always your best value in potentiometers

EXCLUSIVE RELIABILITY PROGRAM

The Bourns Reliability Assurance Program is the only one of its kind in the potentiometer industry. Its primary goal is reliability! It frequently requalifies *all* standard models to insure conformance with published specifications. It also makes available free test data, saving you the time and expense of quality verification. Conducted in *addition* to quality control, it makes Bourns potentiometers the most thoroughly inspected and tested units available.

SUPERIOR QUALITY CONTROL

One-fifth of all Bourns employees work in quality control or reliability monitoring. This is one of the highest personnel ratios of QC employees and inspectors in the electronics industry. In addition, all standard Bourns products undergo extensive in-process and 100% final inspection. These facts help account for the company's return rate of only 0.2% (2 units returned of each 1000 shipped!), one of the lowest on record.

MOST ADVANCED PRODUCTS

As the pioneer in adjustment potentiometers, Bourns has set the standards for an entire industry—in new products, in product improvements, in materials, in processes. Innovations such as the RESISTON® carbon and PALIRIUM® film elements and the virtually indestructible SILVERWELD® termination demonstrate that Bourns is constantly pushing the standards higher.

LARGEST SELECTION

Bourns offers the world's largest selection of potentiometers and an extensive line of precision potentiometers, relays and micro-components. This single-source capability means less shopping around, avoidance of costly specials.

BEST AVAILABILITY

The factory maintains a constant reserve of more than 500,000 units. In addition, more than sixty distributors across the nation carry complete stocks of Bourns adjustment potentiometers. Whatever you need in potentiometers, you can depend on Bourns for an off-the-shelf answer.

OUTSTANDING APPLICATIONS HELP

Bourns maintains a staff of ten professional Application Engineers whose sole job is to give you technical assistance. Each of these specialists serves a specific geographic area. All are extremely able and anxious to help you cut time, corners and costs.

LONGEST EXPERIENCE, RELIABILITY

Bourns—originator of the TRIMPOT® lead-screw-actuated potentiometer—has been making adjustment potentiometers longer than any other manufacturer. Bourns products have the longest reliability record, too, having performed successfully in every major U.S. missile and space program. And the record continues: in today's world-wide markets, far more adjustment potentiometers bear the Bourns label than any other.

COMPETITIVE PRICES

Depth of product line and high production efficiency allow Bourns to meet or beat the prices of competitors—despite its heavy extra expenditure for product reliability. Furthermore, Bourns "holds the line" on prices while continually upgrading its products. In those cases where a Bourns unit is slightly more expensive, you can be sure that the small extra cost means considerable extra value. It is a firm Bourns policy *never* to compromise quality for price.

BOURNS

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MANUFACTURER: TRIMPOT® & PRECISION POTENTIOMETERS, RELAYS; TRANSDUCERS FOR PRESSURE, POSITION, ACCELERATION

F/P-5-101-A

56 Integrated Circuits!

FAIRCHILD MICROLOGIC™—WIDEST LINE IN THE INDUSTRY

MICROLOGIC INTEGRATED CIRCUITS	HIGH SPEED μL MICROLOGIC −55°C to +125°C	INDUSTRIAL FμL MICROLOGIC +15°C to +55°C	MILLIWATT MWμL MICROLOGIC −55°C to +125°C	TRANSISTOR/TRANSISTOR TTμL MICROLOGIC −55°C to +125°C	DIODE/TRANSISTOR DTμL MICROLOGIC −55°C to +125°C	COMPLEMENTARY TRANSISTOR CTμL MICROLOGIC +15°C to +55°C	COUNTING CμL MICROLOGIC 0°C to +75°C
GATES	NAND/NOR 903 3-input 907 4-input 914 Dual 2-input 915 Dual 3-input	NAND/NOR 903, 915 3-input 907 4-input 910, 911 (see MWμL) 914 Dual 2-input Epoxy	NAND/NOR 910 Dual 2-input 911 4-input	103 Dual 4-input 104 8-input	930 Dual 4-input 946 Quad 2-input 962 Triple 3-input	NOR 952 Dual 2-input inverter AND 953 2-2-3-input 954 Dual 4-input 955 8-input	
ADDERS	904 AND/OR 2-level Half Adder	904 AND/OR 2-level Half Adder 908, 912 (see MWμL)	908 EXCLUSIVE OR 912 AND/OR 2-level Half Adder				
BUFFERS	900 Low Impedance	900 Low Impedance Epoxy 909 2-input inverting	909 2-input		932 Dual 4-input 944 Dual 4-input	956 Dual 2-input	
STORAGE ELEMENTS (Flip-Flops)	902 RS 905 GATED RS with inverter 906 GATED RS 926 J-K	923 Epoxy J-K 905 GATED RS with inverter 913 TYPE D 926 J-K	913 TYPE D		931 CLOCKED 945 CLOCKED Low Impedance 948 CLOCKED Low Impedance 950 A.C. Coupled R.S.	957 DUAL RANK	958 DECADE COUNTER CASCADING 959 BUFFER/STORAGE (coming 2nd qtr. '65) 960 DECODER/DISPLAY DRIVER (coming 2nd qtr. '65)
OTHER	901 Counter Adapter	921 EXTENDER Dual 2-input	921 EXTENDER Dual 2-input		933 EXTENDER Dual 4-input 951 MONOSTABLE MULTIVIBRATOR		
PERFORMANCE (Logic form, speed, power, noise immunity, packaging)	RTL; 12 nsec; 15 mW/node; 300 mV; TO-5, Cerpack ¼" x ¼" flat	RTL; 12 nsec; 2-15 mW/node; 300 mV; TO-5, Metal or Epoxy	RTL; 40 nsec; 2 mW/node; 300 mV; TO-5, Cerpack ¼" x ¼" flat	TTL; 25 nsec; 22 mW/gate; 450 mV; Cerpack ¼" x ¼" flat	DTL; 25 nsec; 5 mW/gate; 1.0V; TO-5, Cerpack ¼" x ¼" flat	CTL; 5 nsec; 35 mW/gate; 600 mV; Dual In-Line Industrial type	RTL; TO-5, Dual In-Line Industrial

New circuits in red

Micrologic—Fairchild's brand name for digital integrated circuits.

Micrologic, DTμL, MWμL, TTμL, CTμL, FμL, CμL, μL and μA are Fairchild trademarks.

PLUS—NEW MONOLITHIC LINEAR CIRCUITS

1. High Gain, Wideband D.C. Amplifier—μA702A
Precision instrumentation amplifier for high speed analog systems. Offset voltage: 2mV. Voltage gain: 2800.

2. High Speed Differential Comparator—μA710
Variable-threshold Schmitt trigger. Pulse height discriminator. Memory sense amplifier. Compatibility with all integrated logic forms. Offset voltage: 3mV. Response time: 50nsec.

FAIRCHILD SEMICONDUCTOR

EASTERN **ALABAMA** *Huntsville: Schweber Electronics, 539-2756.* **CONNECTICUT** *Hamden: Cramer Electronics, 288-7771.* **FLORIDA** *Orlando: Crescent Electronics Sales, 423-8586; Hall Mark Electronics Corp., 855-4020.* **MARYLAND** *Baltimore: Valley Electronics, NO 8-4900/D. C. Area: Powell Electronics, 474-1030.* **MASSACHUSETTS** *Newton: Cramer Electronics, WO 9-7700/Watertown: L. L. Schley Co., WA 6-0235.* **NEW JERSEY** *Cherry Hill: Valley Electronics, NO 2-9337.* **NEW YORK** *Baldwin, L.I.: Taylor Electronics Corp., 223-8000/Buffalo: Dart Sales, 684-6250; Summit Distributors, 884-3450/Syracuse: Dart Sales, GL 4-9257; Eastern Semiconductor Sales, Inc., 455-6641/Westbury, L.I.: Schweber Electronics, ED 4-7474.* **PENNSYLVANIA** *Philadelphia: Powell Electronics, 724-1900.* CENTRAL **ILLINOIS** *Chicago: Avnet Electronics, 678-8160; Semiconductor Specialists, 622-8860.* **MICHIGAN** *Detroit: Semiconductor Specialists, LU 4-5901.* **MINNESOTA** *Minneapolis: E. C. Electronics Sales, 888-4626; Semiconductor Specialists, UN 6-3435.* **MISSOURI** *St. Louis: Durbin-Hamilton Electro Corp., 966-3003.* **OHIO** *Cincinnati: Sheridan Sales Co., 761-5432.* **TEXAS** *Dallas: Norvell Associates, FL 7-6451/Houston: Norvell Associates, MO 5-0558.* WESTERN **ARIZONA** *Phoenix: Hamilton Electro, 272-2601; G. S. Marshall Co., 946-4276.* **CALIFORNIA** *Los Angeles: Hamilton Electro, 870-3300/Palo Alto: Hamilton Electro, 321-7541/Redwood City: G. S. Marshall Co., 365-2000/San Diego: Denny-Hamilton Electronics, 279-2421; G. S. Marshall Co., 278-6350/San Marino: G. S. Marshall Co., MU 1-3292.* **COLORADO** *Denver: Hyer Electronics, 771-5285.* **NEW MEXICO** *Albuquerque: Hyer Electronics, 268-6744.* **WASHINGTON** *Seattle: Hamilton Electro, 282-3886.* **CANADA** *Toronto, Ontario: Avnet, 789-2621; Montreal, Quebec: 697-1993.*

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FAIRCHILD SEMICONDUCTOR/A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION/313 FAIRCHILD DR., MOUNTAIN VIEW, CALIF./962-5011/TWX: 910-379-6435

Editorial

No time for timidity

Speaking on the West Coast earlier this month, David Rockefeller, president of New York's huge Chase Manhattan Bank, offered some advice to companies hurt by declining military sales. He urged them to move boldly into nondefense activities as if they belonged there, not timidly, like usurpers.

"Many defense contractors do themselves an injustice in conveying the impression that they can work only on missiles and space vehicles," the banker said. "The fact is that they are in the problem-solving business and this nation is a long way from running out of problems."

A lot of these problems have been around for a long time, but attention is just being focused on them. For example, the colossal traffic jams that tie up every city in the world; the demand for good education by millions of people, though the supply of teachers is forbiddingly limited; the mushrooming complexity of government at all levels—city, state and federal; the upswing in preventive medicine; and the replacement of human organs by artificial ones.

There is still plenty of government money around, and a lot of it never sees the Pentagon. Municipalities and states are stepping up their expenditures for research and development and for electronic solutions to some of their problems. On the national level, some of the most interesting projects in the next few years will be coming from the Department of Health, Education and Welfare, rather than the Defense Department.

Engineers at a few electronics companies, which have been best known for their activity in military or space electronics, are getting their feet wet in this new area. The Sperry Rand Corp., for example, is working on a project to untangle New York City's traffic; Cubic Corp. has perfected an electronic vote counter; Non-Linear Systems, Inc., is developing an electronic teaching machine; and the State of California has commissioned three aerospace companies to work on unique projects. A subsidiary of Aerojet General, the Space General Corp., which had developed a biological warfare warning system for the military, is now studying how aerospace technology might be applied in the war on juvenile delinquency; the North American Aviation Co. is examining the transportation of people and freight in urban areas; and the Lockheed Aircraft Corp. has a contract to pursue what many people say may lead to a giant electronics market, information flow in government.

Clearly, there is money available to companies with practical ideas that may solve pressing problems.

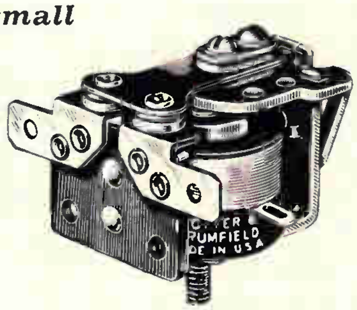
But there is more—there is also great satisfaction to be earned. Even those few engineers who have had quiet doubts about pouring their creativity into implements of war can join unreservedly in a project to improve education, care for the sick, better urban living or ease the paperwork of government.

It is sheer waste not to find new uses for the powerful technology that has been developed in the past ten years for military and space applications. In his speech, Rockefeller said sarcastically, "It seems reasonable to assume that the 'brain teams' that have figured out how to put a man on the moon should be able to get a man to work a little more quickly and efficiently."

The answer to many of the problems of daily living is in electronic equipment. The challenge is there; the opportunity is there; even the money is there. What's missing, however, is the bold entry of more electronics companies into unfamiliar areas of application.

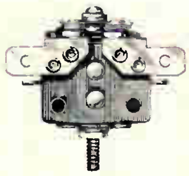
This P&B relay switches 20 amperes, costs only $3.90 each, is available from leading parts distributors...*

and it's this small



Here is a real space-saving power relay —ideal for applications where limited space is a factor. *Three* KR3 relays will fit in the space required for *one* 20-ampere relay of most other makes. The KR3 occupies only little more than one and a half cubic inches.

Installation is simple, too. Standard KR3 relays have a convenient stud and mounting tab—and the contact terminals will accept ¼" quick-connects or solder connections.



Field-proved for more than a year, the KR3 is available for immediate shipment from authorized P&B distributors. Tests show mechanical life will exceed one million operations . . . and the twin contacts are rated at 20 amperes at 115V AC, 60 cycles resistive or 28V DC, 1 HP 115/230V 60 cycles.

Relays ordered from the factory can be supplied in clear, high-impact polycarbonate case with octal plug.

For complete information, call your nearest P&B sales representative or write direct. Remember . . . you can buy cheaper relays but you cannot buy P&B quality for less.

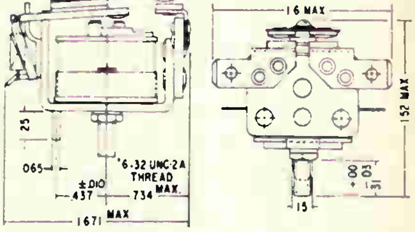
ENGINEERING SPECIFICATIONS

GENERAL:
Insulation Resistance: 1000 megohms.
Expected Life: 1 million mechanical operations, min.
Breakdown Voltage: 500V rms 60 cycles bet. all elements.
Temperature Range Open Relay | AC and DC: −45°C min. AC: +70°C max. DC: +85°C max.

CONTACTS:
Arrangements: SPST-NO-DB (1 Form X) only.
Rating: 20 amps @ 115V AC, 60 cycles resistive, or 28V DC; 1 HP 115/230V 60 cycles.

COILS:
Voltage: DC: to 110V
AC: to 230V
Power: DC: 1.2 watts min.
AC: 2.0 volt-amps.
Resistance: 16,500 ohms maximum.
Duty: Continuous.

MOUNTING:
Open: One 6-32 stud and ¼" locating tab on 7/16" centers.
Enclosed: Octal socket.



**Unit price for 6 to 115V AC models. Quantity discounts available.*

RIDE THE AMF MONORAIL AT THE NEW YORK WORLD'S FAIR

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In Canada: Potter & Brumfield, Division of AMF Canada Ltd., Guelph, Ont.
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Electronics Newsletter

June 28, 1965

RCA to double color tv output

The Radio Corp. of America is planning the largest expansion program in its 46-year history to meet the demand for color television receivers and picture tubes. **It will spend $36.4 million to double its color tube production in three years and $13.3 million to double receiver output in two years.**

Despite the shortage of color picture tubes—the industry could sell half a million extra sets this year if tubes were available, according to RCA sources—RCA has decreased its expected output for this year from 1.5 million to 1.35 million. Reason: The company will switch its production as quickly as possible to 25-inch rectangular tubes, and it cannot make these tubes as fast as the 21-inch round ones.

Though the round tube will amount to 75% of RCA's output in 1965, it will be phased out of production, except for the small replacement market, by late 1966.

One-gun color tv scores hit at show

The most popular exhibit at the IEEE conference on radio and television receivers in Chicago was a completely transistorized dot-sequential color receiver made by the Semiconductor division of the Fairchild Camera & Instrument Corp. The set uses a one-gun Chromatron color tube.

Fairchild also showed an f-m tuner using metal-oxide semiconductor field-effect transistors and an integrated circuit in the intermediate frequency stage. The circuit, which has five elements, can also be applied to the i-f stage in a tv receiver. Fairchild said the integrated circuit chip should cost well under a dollar—about the price of a single-element i-f stage with discrete components—by early next year.

Television-set producers were generally cool toward the large-screen transistorized prototypes shown by semiconductor manufacturers. They say consumers won't spend the extra money for solid state circuitry in large receivers, since there can be no significant reduction in size.

New computer uses titanium circuits

The titanium thin-film production techniques developed several years ago by Lockheed Aircraft Corp.'s Missiles and Space division are about to have their first large-scale application in commercial electronics.

Pacific Data Systems, Inc., is set to introduce a computer with titanium circuits that may be the first commercial analog computer made with microcircuits. PDS hasn't disclosed any details of the computer type or circuits, but the company is a subsidiary of Electronic Associates, Inc., a leading manufacturer of analog and analog-digital computers.

The chief commercial attraction of the unique Lockheed process is the low cost of thin-film production and hybrid microcircuit assembly. All the passive components are made chemically from a single plated thin film.

The plating can go into holes in the substrate and regularly packaged components, such as transistors, can be added by dip soldering.

IC's to cut cost of big instrument

A dollar a circuit—that's how much the Nuclear-Chicago Corp. will cut the price of scintillation-counting system by using 350 monolithic logic circuits. **It is one of the first large instruments to be made commercially**

with integrated circuits. The 350 off-the-shelf Signetics Corp. circuits replace 6,000 discrete components, saving assembly labor.

Deliveries of the new system, which is used for radiation measurements, will start in September. The price is $14,200, which is $500 more than the price of a comparable discrete-component model; but unlike the discrete-component unit, the new model does not require an $850 external calculator. The new system makes the calculations internally and prints out the results.

Nuclear-Chicago built in the calculator and printout, resulting in economies in manufacturing, packaging and system design that exceed the added cost of integrated circuits over discrete components.

Airline to install Collins altimeters

The Collins Radio Co. has received the first large order for radio altimeter systems. **United Air Lines will spend $1 million to install them in 164 of its jets.**

The Collins AL-101 altimeter measures terrain clearance from 2,500 feet down to touchdown for automatic instrument landings.

Litton Industries, Inc., has sold a few similar systems to other airlines, but United's order calls for equipping its entire fleet, plus all aircraft it buys for the next two years, with radio altimeters.

Bright future seen for Air Force MOL

Air Force officials are sanguine about winning Defense Secretary McNamara's approval for the Manned Orbiting Laboratory (MOL) program, but the Pentagon will say only that a decision should be reached soon.

Two factors contribute to the surge of optimism: the stunning success of the Titan 3C, which is large enough to lift MOL into orbit, and the spectacular performance of the astronauts in Gemini 4, showing that man can work in space for extended periods.

Vidicon camera weighs 3 pounds

A three-pound camera, believed to be the smallest vidicon television package yet developed, has been designed by Teledyne, Inc., which says **the 4½-by-3½-by-1½-inch device is nearly ready for demonstration.**

The new camera includes in a single package all the integrated circuitry and control electronics necessary for producing a standard video picture. The camera is being developed under a contract with the National Aeronautics and Space Administration's Marshall Space Flight Center. It would be used to monitor instrumentation on flights of the Saturn rocket.

Proposals due on moon package

Industry proposals are due July 13 on a portable experimental package containing eight scientific experiments that U.S. astronauts will deposit on the moon. **The National Aeronautics and Space Administration will award as many as three concurrent design studies.**

Later, there will be a multimillion-dollar contract to one of the companies for the development of the package from which astronauts will assemble and set up instrumentation for measuring the physical conditions on the moon.

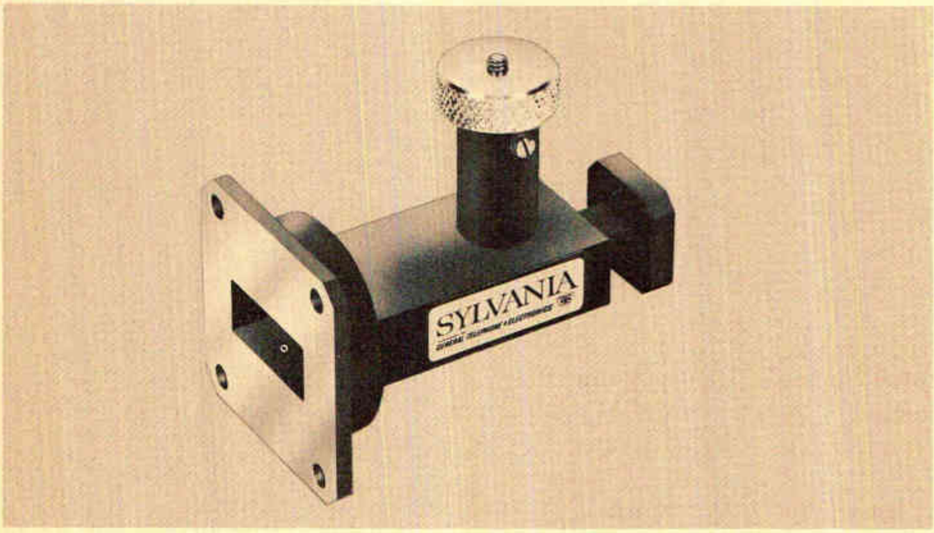
Component and Circuit Design

IDEAS

from SYLVANIA Electronic Components Group

MICROWAVE COMPONENTS

A new approach to Ka-band power (SYG-2001)



Until just recently, a Ka-band klystron was the most practical means of obtaining Ka-band power. While the short-range performance of a Ka-band klystron was often satisfactory, service life was at best limited, often less. Another consideration, the Ka-band klystron has always been costly.

A new component by Sylvania, a high-frequency waveguide tripler, is proving itself as an excellent replacement for Ka-band klystrons. It has the big advantage of providing economical Ka-band power with X-band reliability. As a simple method for converting X-band to Ka frequencies, this Sylvania tripler can be ideal for commercial communications equipment, military radar systems and test equipment bench usage.

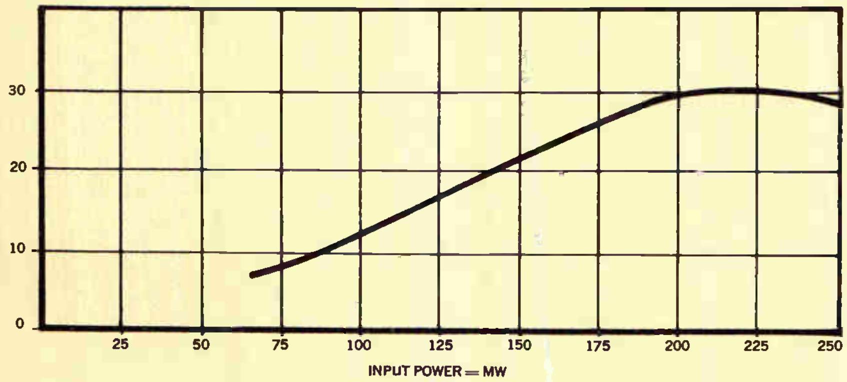
The SYG-2001's reliability and stability are evidenced by recently completed tests where the unit was run continuously without adjustment or interruption for thirteen months. This performance indicates the long-range cost savings possible by reducing klystron replacement. Sylvania's waveguide tripler delivers Ka-band power at X-band costs.

The SYG-2001 is available throughout the range of its RG-52/U input waveguide; it can be designed to any specific frequency in the Ka-band spectrum. This Sylvania multiplier uses a special D-5245D gallium arsenide varactor diode and can be supplied with or without an X-band klystron driver.

Its important characteristics include a 25% minimum efficiency, a guaranteed minimum output power of 50 milliwatts and an output bandwidth of 300 megacycles.

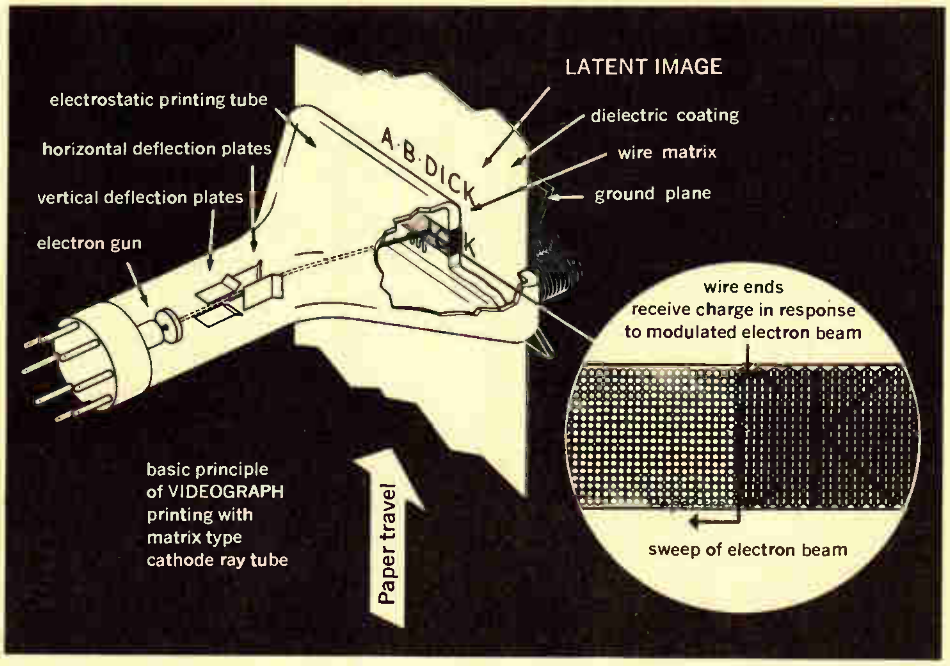
Without an X-band klystron or waveguide transition attached, the SYG-2001 is 2.75 inches long and weighs 6 ounces. It can be mounted in any position without sacrifice to performance.

CIRCLE NUMBER 300



This issue in capsule

Simplify printing problems with character-producing CRT's



It's a well-known fact that character-producing cathode ray tubes are playing an increasingly large role in non-impact printing systems. For example, modern CRT's are essential to data output printers on high-speed computers; they're also vital to facsimile data-transmission systems.

CRT's have achieved a large measure of success in solving a major problem of mass-circulation magazines—namely, the high-speed printing of individual addresses in minimum time periods. A Sylvania monoscope and a Sylvania electrostatic charge printing tube, for instance, are at the very heart of A. B. Dick's high-speed non-impact label printers, which can produce some 135,000 address labels per hour. The 3-inch monoscope tube generates as many as 30,000 characters per second. The electrostatic printing tube (EPT) is used for printing the same characters onto labels in heavy rolls.

The A. B. Dick Co. designed these tubes into its remarkable Model 910 Videograph Address-Label Printer, a highly automated web-type printer that achieves these huge production rates of 135,000 labels an hour. A single operator can continuously operate the Videograph because of other automated features, including paper splicing and roll changing.

Basic to high-speed electrostatic printing in the Model 910 is its ability to use video signals to write character images on a moving web of dielectric coated paper. These signals are generated by a digital-to-alphanumeric monoscope-type converter which uses a Sylvania SC-3093, a special 3-inch monoscope. This tube is capable of generating video signals for 64 different characters or symbols at a rate of 20,000 to 30,000 characters per second.

Another CRT, the Sylvania Type SC-2795, is used for electrostatic charge printing. The tube has no phosphor screen. Instead, a matrix of extremely fine wires extends through and is sealed into the faceplate. There are 62,500 wires per square inch of faceplate surface on the EPT. To print, video signals are applied to the deflection yoke or plates: the video signals cause the electron beam of the EPT to move and write character forms on the inside of the wire matrix faceplate. The outer side of the wire matrix faceplate is in contact with the moving dielectric paper. As the electron beam strikes the wires, current passing through them places an invisible electrostati charge pattern (latent image) on the paper. The pattern on the paper conforms to the characters written by the EPT electron beam.

The moving paper then goes through a developer hopper where the latent image is made visible by toner application. When the paper goes through the fixing process printing is complete and the paper is wound onto one of the spindles in the take-up turret.

At the printer, the horizontal displacement of the electron beam in the electrostatic printing tube is synchronized with the horizontal rate of scan, which is the same as the speed at which paper is fed past the EPT. With both of these actions synchronized, any variation in tonal value of the original document is reproduced by the printer. This means that pictures as well as printed data can be transmitted and reproduced.

The version of the electrostatic printing tube used for facsimile reproduction has a narrow band of wires which spans the width of the tube instead of the wide matrix of wires used in digital printing applications. This type of electrostatic printing tube is the Sylvania SC-314 or SC-3154. Facsimiles of documents measuring 8½ inches by 11 inches are printed on a continuous roll of paper at the rate of 10 per minute.

The inherent advantages of Videograph electrostatic printing over mechanical printers include high reliability, great speed, and versatility in selection of character sizes and line spacing.

CIRCLE NUMBER 301

SYLVANIA·SC2795

SYLVANIA·SC3093

Sylvania multiple diodes save time, solve high-speed switching problems

Matched monolithic diodes by Sylvania can be the perfect solution to high-speed switching problems. Packaged in pairs, triples and quads, each of these units has either common cathodes or common anodes.

The principal advantages to these multiple diodes are reliability and a savings in assembly time resulting from fewer external connections. Their extraordinary reliability is assured in careful matching of diode-to-diode characteristics for uniformity of performance, as well as by hermetic sealing in a dry ambient.

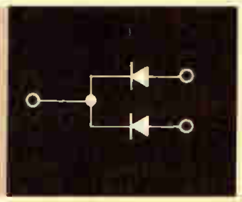
Still other devices in Sylvania's epitaxial multiple diode line are the diode bridges and ring modulators described here in the tabular matter.

All of these units are supplied in TO-46 packages with 3 or 4 leads.

CIRCLE NUMBER 302

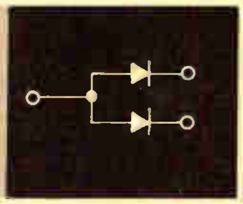
Common Cathode Diodes

Type No.	No. of Diodes	PRV Volts	Max. Fwd. Current ma	Fwd. Current @ 1.0V na	Recovery Time T_{rr} nsec	Capacitance 0V—1 mc
SID2A-1	2	40	225	100	3.0	4.5
SID2A-2	2	75	200	75	3.0	3.5
SID2A-3	2	100	175	50	3.0	2.5
SID2A-4	2	40	175	20	4.0	4.5



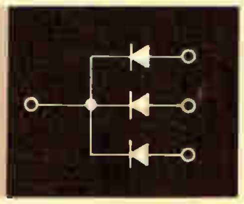
Common Anode Diodes

Type No.	No. of Diodes	PRV Volts	Max. Fwd. Current ma	Fwd. Current @ 1.0V na	Recovery Time T_{rr} nsec	Capacitance. pf 0V—1 mc
SID2B-1	2	40	175	20	4.0	5.0
SID2B-2	2	75	200	75	3.0	4.5
SID2B-3	2	40	225	100	3.0	5.0



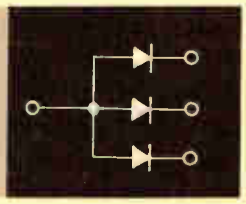
Common Cathode Diodes

Type No.	No. of Diodes	PRV Volts	Max. Fwd. Current ma	Fwd. Current @ 1.0V na	Recovery Time T_{rr} nsec	Capacitance 0V—1 mc
SID3A-1	3	40	225	100	3.0	4.5
SID3A-2	3	75	200	75	3.0	3.5
SID3A-3	3	100	175	50	3.0	2.5
SID3A-4	3	40	175	20	4.0	4.5
SID3A-6	3	100	225	100	3.0	2.5



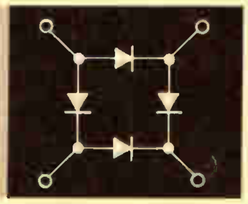
Common Anode Diodes

Type No.	No. of Diodes	PRV Volts	Max. Fwd. Current ma	Fwd. Current @ 1.0V na	Recovery Time T_{rr} nsec	Capacitance 0V—1 mc
SID3B-1	3	40	175	20	4.0	5.0
SID3B-2	3	75	200	75	3.0	4.5
SID3B-3	3	40	225	100	3.0	5.0



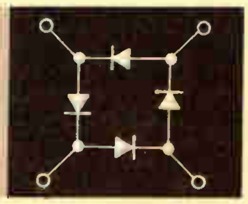
Diode Bridge

Type No.	No. of Diodes	Fwd. Current @ 1.0 Volts ma	PRV V	Matching Fwd. Current @ 2 ma mv
SID4C-2	4	30	50	——
SID4C-3	4	50	75	20



Ring Modulator

Type No.	No. of Diodes	Fwd. Current @ 1.0 Volts ma	Matching Fwd. Current @ 2 ma mv
SID4D-1	4	50	20



Solid state reliability proven in 345,000-hour test

The "solid state reliability" of electroluminescence (EL) has been talked about at length in recent years. But, above and beyond the fact that there are no filaments and no vacuum, what can the term mean to a design engineer?

In a continuing series of life tests, a total of 4,648 individual EL lamp segments were tested for 345,478 hours. At the conclusion of this lengthy trial, there had not been a single incident of catastrophic failure, long a problem with other readout systems. Because the EL segments are phosphor-using, solid state devices, abrupt failure was again proved virtually impossible.

Rather than be concerned with a burn-out or total failure the EL user must instead evaluate the point at which a device may need simple replacement after considerable usage. Although light output does diminish, the remaining brightness can be adequate for continued long-life service. Programmed replacement can be done on a planned downtime basis.

Reliability of this order is inherent in both special designs as well as in standard EL product lines. Basically, the product line consists of 7- and 9-segment digits in numeric panels and a 14-segment character in alphanumeric panels. Panels are available in both single and multi-digit designs that can also display special symbols.

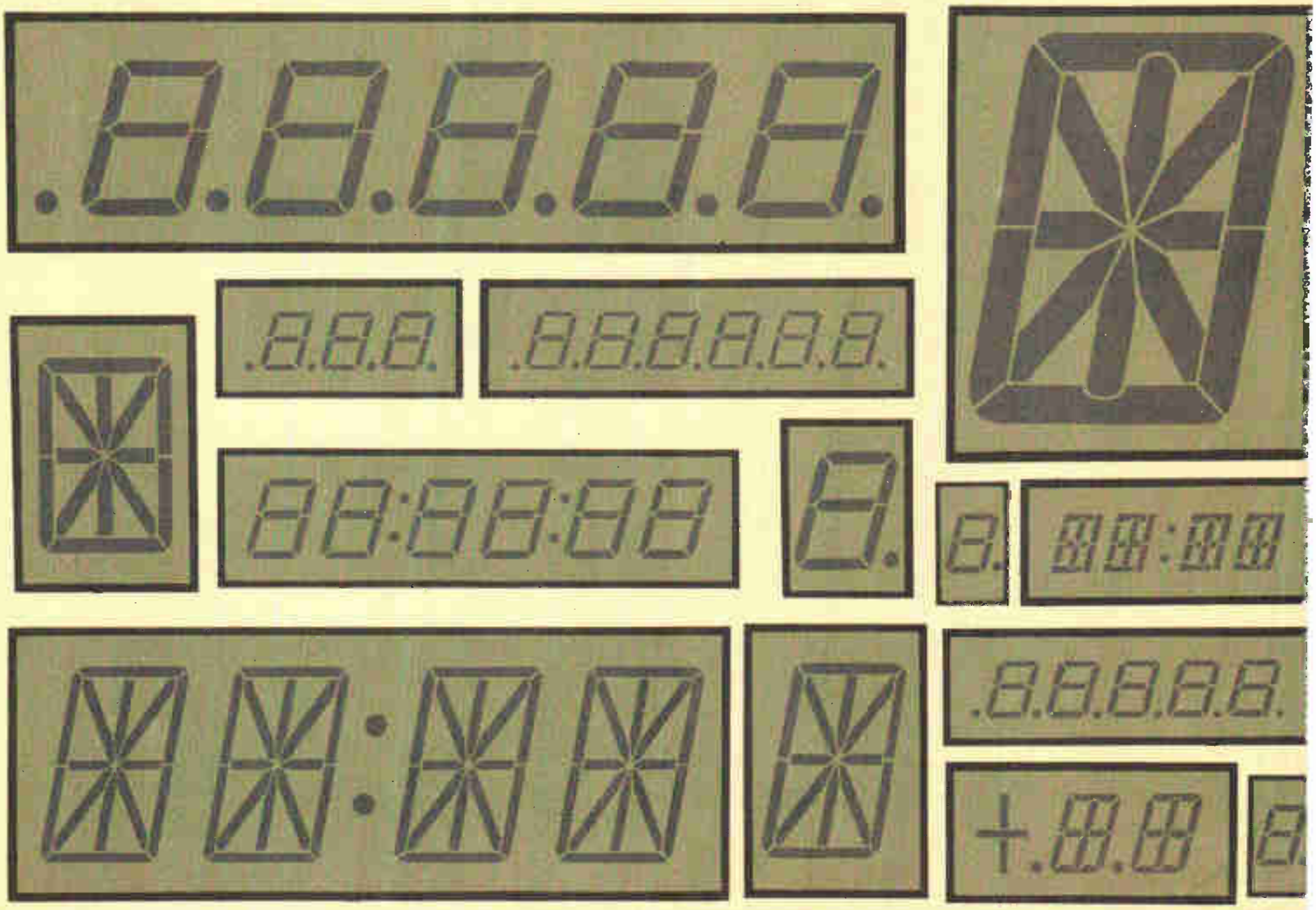
Many other product pluses come with EL. For instance, because of its flat, single plane design, the EL readout can be viewed from almost a 180-degree viewing range. There is minimum chance for error in viewing from wide angles because of its in-plane presentation. And because the lighted area is behind a thin glass substrate, the viewing problems associated with stacked numbers are eliminated.

Many engineers are finding that EL's small physical size solves problems caused by limited space. Solid state construction has allowed Sylvania to design standard units in the smallest depths ever made commercially available in readout systems. EL also has the capability of presenting multi-numerics in small character sizes, spaced as close as clear readability will allow. Sizes as small as ½-inch can be ideal for such applications as frequency counters and navigational equipment. Larger sizes are preferred for schedule boards, elevator systems, silent-pager systems and dispatchers.

EL readouts are well-known for other outstanding features. There is no radiation, proven in standard military tests over a range of 14 kc to 1000 mc. Power requirements are low: e.g., a ¾-inch numeric requires only 7 mw with all segments energized. EL's graphic versatility is another product-plus; almost any special symbol can be fabricated and displayed easily and inexpensively.

CIRCLE NUMBER 303

Array of EL display panels shows variety in character size (½" to 6"), numeric style (7- & 9-segment), and alphanumeric style (14-segment).



How two new J-K flip-flops save packages, power and time

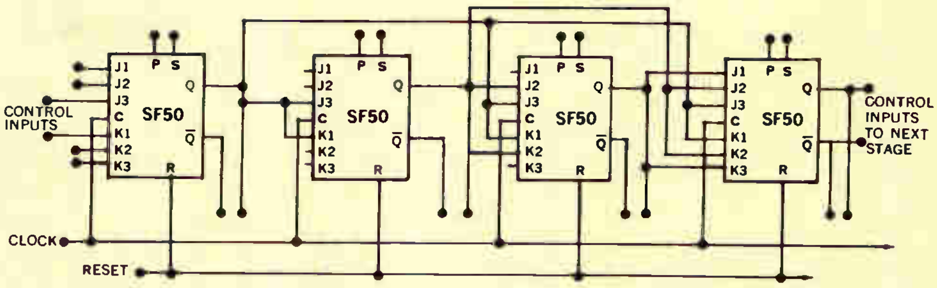
Two remarkable new J-K flip-flops from Sylvania are proven low-cost solutions for counter and shift register circuitry in improved computer systems design.

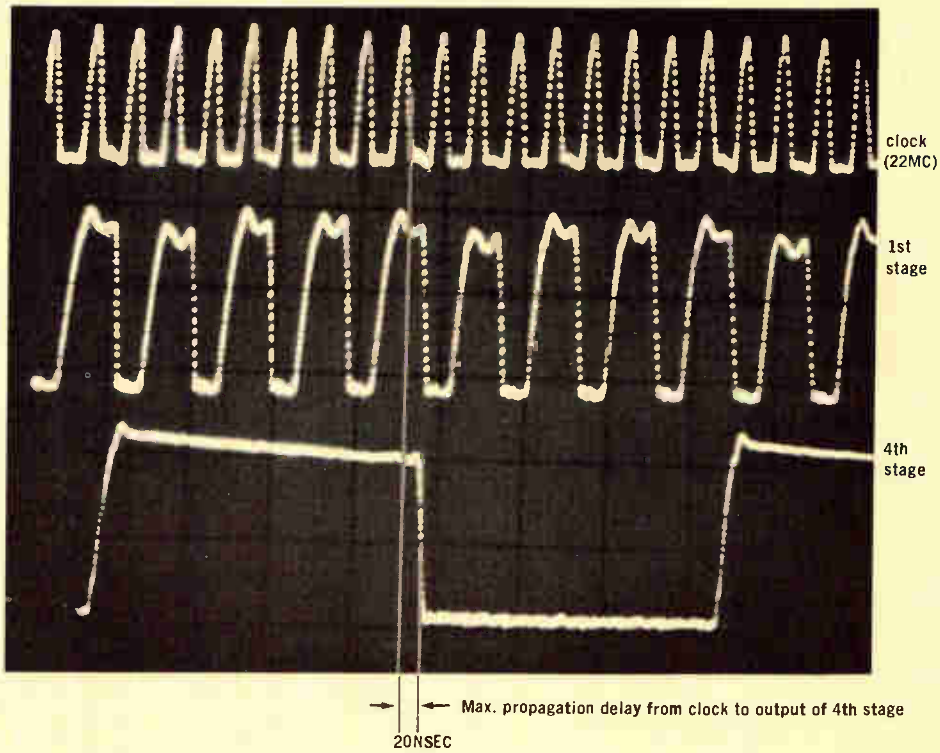
For example, the SF-50 J-K, which AND's up to three inputs on both the J and K terminals, provides an effective circuit for 20-megacycle counter designs.

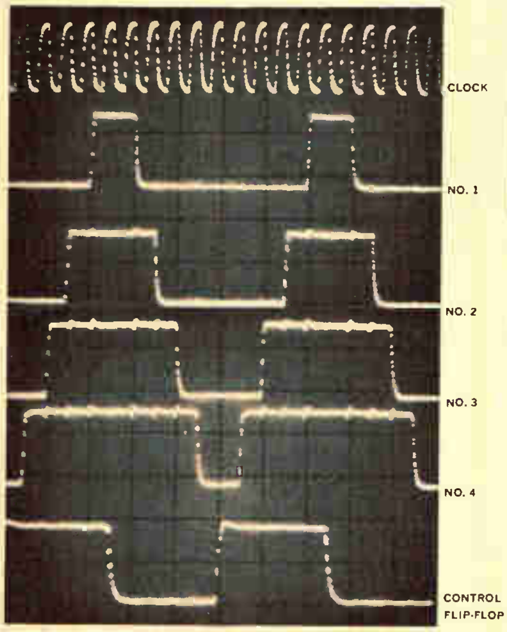
The newest OR input J-K, SF-60, simplifies and improves shift register designs. This 20-megacycle shift-left/shift-right register can be built with just four J-K SF-60 flip-flops (OR input).

This versatile register can be used as a count-up/count-down counter in the arithmetic portion of a computer. Both the shift register and the counter designs (shown here) save gate packages, power, interconnections, layout time and money without sacrificing speed, noise immunity, fanout or capacitance drive.

20 mc synchronous 4-stage binary counter



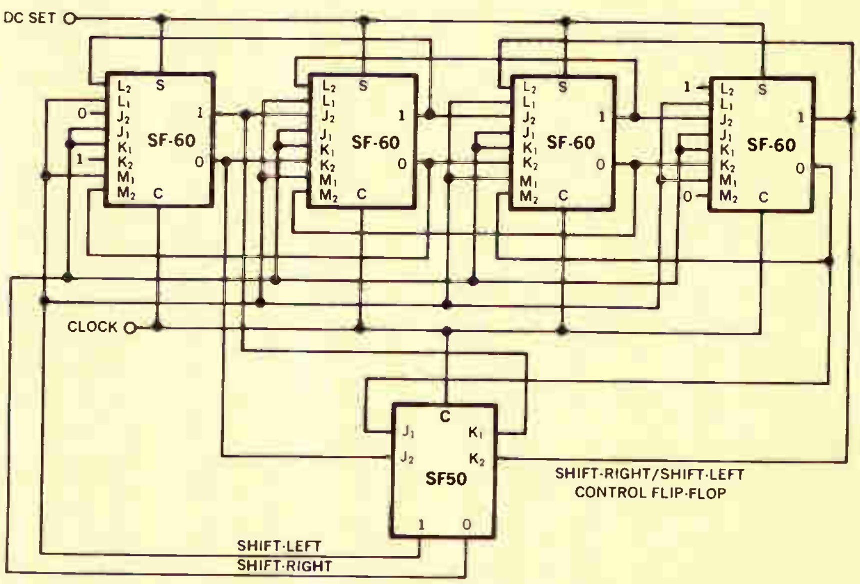




STAGE NO. 1	STAGE NO. 2	STAGE NO. 3	STAGE NO. 4
0	0	0	0
0	0	0	0
0	0	0	1
0	0	1	1
0	1	1	1
1	1	1	1
1	1	1	1
0	1	1	1
0	0	1	1
0	0	0	1
0	0	0	0
0	0	0	0

AT THIS POINT IN TIME THE CONTROL FLIP-FLOP IS PRIMED AND AT THE NEXT CLOCK IT ENERGIZES THE SHIFT-LEFT LINE.

Automatic shift-right/shift-left register



COLOR TELEVISION

New York TV station updates monitor with color bright 85 picture tube

In a move to improve its monitoring equipment, New York station WOR-TV has installed a 21" *color bright 85* picture tube at its master control. The color picture tube selected, a Sylvania Type RE21FJP22, is a bonded anti-reflection rare-earth round cathode ray tube.

True color fidelity is the principal advantage of the *color bright 85* tube in a monitor site. It is here where technicians insure that the best possible balance between colors is being transmitted. The natural reds of Sylvania's rare-earth *color bright 85* tube now allow master control staffs to evaluate the color mix in its proper perspective.

Before the advent of this tube, the only color picture tubes available were industry standard sulfide types. The traditional red color in these tubes was actually an orange-red that tended to turn even more orange as the brightness increased. The *color bright 85* tube changed this with its natural europium-red phosphors, which remain a true red under all conditions. The newer phosphors, coupled with Sylvania's own air-spun screening process, assure precisely displayed images on the face of the tube.

CIRCLE NUMBER 305

PRODUCT MANAGER'S CORNER

The "color" renaissance of receiving tubes

In the late forties and fifties much effort was exerted by the industry in circuit simplification, receiving tube versatility, and in other programs aimed at bringing black-and-white TV receiver costs down to reach the mass market. The results are well known. Color TV is following a similar pattern. However, the accomplishment here is expected to be much more rapid.

The present color surge may be said to be providing a renaissance for receiving tubes, but in truth it is actually an extension of the receiving tube's usefulness, enhanced by its more recent tremendous strides in reliability and performance.

Having recognized these considerations a number of years ago, Sylvania has been carrying on a continuing development program designed to introduce better performing tubes and, at the same time, allow for the possibility that the overall cost of a given function in the receiver be reduced. One result is the new "Sylvania Receiving Tubes for Color" program which provides tubes for those critical functions in the color set that can perform at 125 to 150 volts *lower* "B" supply than before. At the same time the new Type 9KC6 strap frame grid dual control pentode and its associated chroma bandpass circuitry now provide a cost reduction in the overall function along with improved performance.

The above-mentioned development program is not limited to color TV alone; effort is also being expended for black-and-white. It is recognized that one of the greatest advantages of the receiving tube is that it can be manufactured in a predetermined manner with a very narrow range in characteristic variations. This allows the TV set manufacturer a greater degree of freedom, not just in set design but in actual set production as well. In the latter case, for example, because of the receiving tube's narrow spread in characteristics, there is no need to run many variations of the same chassis down the production line to accommodate receiving tubes. On the contrary, it is known that, due to diverse reasons (e.g., various components running near their own characteristic limits all in the same direction, or the set manufacturer revising set specifications), the receiving tube has on occasion been redesigned in a matter of hours and put into the lines to resolve the problem.

Beyond the receiving tube's excellent technical and economic performance in the set and on the lines, there's the matter of great strides made in reliability, especially in recent years. Sylvania has been running comprehensive evaluations of receiving tube reliability in different makes and models of TV sets for more than a dozen years. Recent data show that the average receiving tube, all sockets lumped together along with the various types of black-and-white receivers, should have an MTBF (mean time between failure) greater than 500,000 hours at normal operating conditions. This is an order of magnitude better than that achieved a decade ago and is the result of continuing efforts toward better processing methods and better materials, such as, for example, the use of powder metal cathodes and rhenium tungsten heaters.

Being newer, there is less cumulative information on the reliability of receiving tubes in color TV. However, available data do indicate that the MTBF of the receiving tube here should be better than 300,000 hours. This present lower figure is due to the more critical demands of the color TV set over black-and-white. But, with increased experience and with continuing development programs, it is expected that the MTBF of receiving tubes in color sets will soon exceed 500,000 hours.

It's hard to beat performance and reliability like this!

Al Dolnick

A. L. DOLNICK

MICROWAVE DIODES

Speed (1 ns), isolation (35 db), low insertion loss (1 db) – all in one switching diode

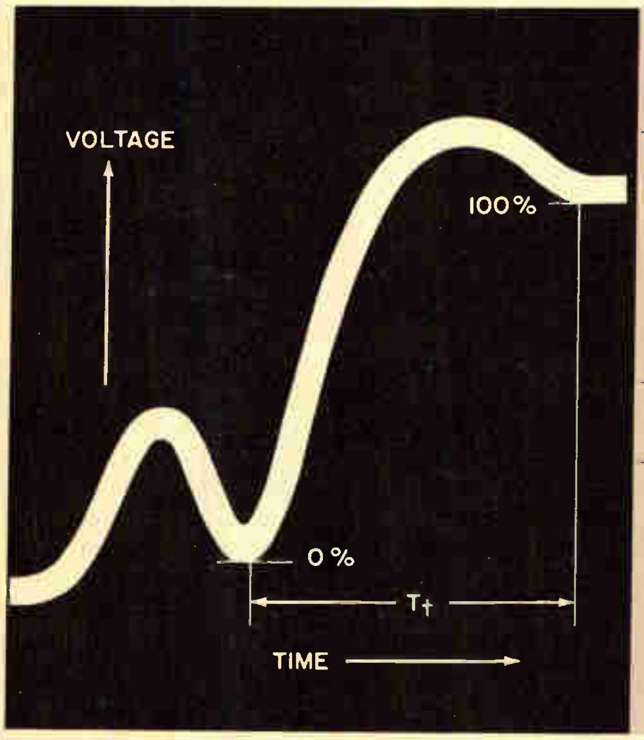
Problem #1: Design high resolution radar equipment which must handle narrow pulse widths with maximum fidelity.

Problem #2: Find a Ku-band switching diode to do the job.

Performance previously unavailable in a microwave switching diode is now offered in the Sylvania D-5151A. A unique combination of package and junction characteristics results in a maximum switching time of 1 nanosecond from 10% to 90% values, with a 35 db isolation possible in the "off" position and 1 db insertion loss in the "on" state.

Capability of this order can be vital to designers of specialized equipment for high resolution radar or high-speed modulators for multiple transmission microwave data links.

The D-5151A's unique construction techniques result in extremely low junction capacities (typical .1 pfd.), which make possible low loss switching at X- and Ku-band.



PERFORMANCE DATA
POLARITY: Forward or Reverse.

ABSOLUTE MAXIMUM RATINGS:

Storage Temperature Range, T_{stg}	—65°C to 150°C
Operating Junction Temperature, T_{op}	—65°C to 150°C
Lead Temperature 1/16" ± 1/32" from case for 10 seconds.	175°C
Maximum Power Dissipation, P_{diss}	250 mw
Derating Factor	—2 mw/°C
Maximum Working Voltage, V_R (D-5151)	50 vdc
Maximum Working Voltage, V_R (D-5151A)	80 vdc

ELECTRICAL CHARACTERISTICS (25°C):

	D-5151	D-5151A
Breakdown Voltage, BV, I_R = 10 μa	50 v min.	80 v min.
Total Capacitance, C_T, V_R = —30 v, Freq. = 100 kc	0.20 pf max	0.10 pf max.
Dynamic Forward Impedance, Z_F, I_F = 40 ma	3.75 Ω max.	3.0 Ω max.
Transition Time, T_t	less than 2.5 ns	
Package Capacitance	0.05 pf	
Package Inductance	1.4 nh in a 50 Ω line	

CIRCLE NUMBER 306

HOT LINE INQUIRY SERVICE

Use Sylvania's "Hot Line" inquiry service, especially if you require full particulars on any item in a hurry. It's easy and it's free. Circle the reader service number(s) you're most interested in; then fill in your name, title, company and address. We'll do the rest and see you get further information almost by return mail.

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ELECTRONIC SURGE ARRESTORS

New 110-coulomb units customed to uses from 60 cycles to 2 mc.

The newest line of Sylvania surge arrestors for both new and retrofit use is the best equipment protection available today at time of enemy attack. The importance of this equipment protection is obvious: it can be the essential ingredient in maintaining many vital functions such as military readiness and power distribution systems.

Basic to these surge arrestors is Sylvania's Type SG-1360 spark gap series, designed to meet the most rigid requirements, including both industrial and military applications. These spark gaps prevent against transient overloads such as those generated with a lightning strike. All units are built to withstand repeated high energy charges.

Requirements for the respective frequency ranges are as follows:

	Frequency	Voltage Breakdown
Audio Frequency	60 to 2,000 cycles	300 to 1K Volts
Mid-Frequency	2,000 cycles to 2 mc	500 to 1.2K Volts
High-Frequency	2 mc to 30 mc	800 to 1.5K Volts

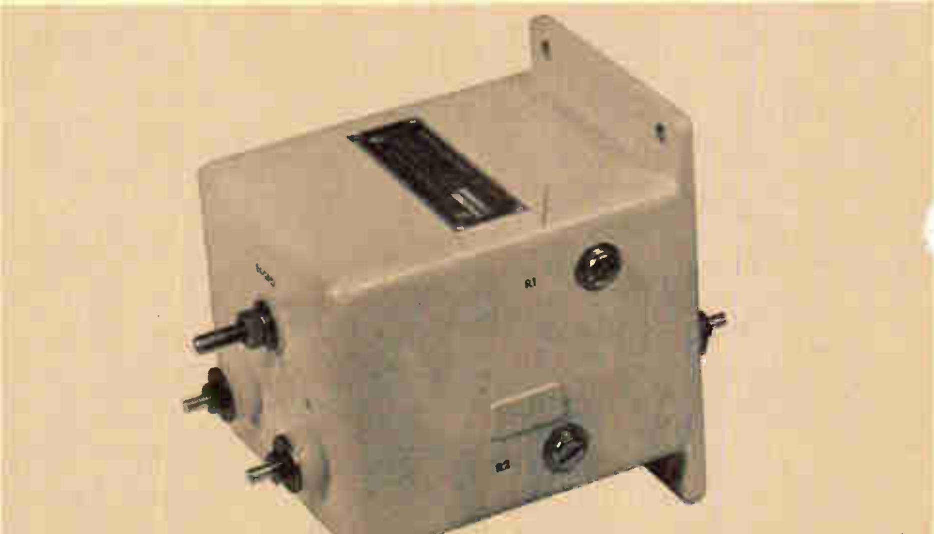
The audio electronic surge arrestor uses a 20-ohm wire-wound precision resistor in each line as secondary protective devices to avoid transient effects. The mid-frequency version requires an especially designed transformer to provide secondary protection in conjunction with the spark gap.

The high-frequency surge arrestor has an especially designed transformer and special transmission lines for secondary protection in the higher frequencies.

These devices are all designed around three metal alloy electrodes hermetically sealed in a ceramic and metal package. This basic SG-1360 spark gap design is essential to the surge arrestor's capability of switching a total of 110 coulombs, or 55 coulombs per line.

The 60-cycle breakdown voltage can be varied from 300 to 1100 volts. This breakdown is arrived at by precise spacing of the line-to-ground electrodes along with proper selection of inert gas used for backfilling.

CIRCLE NUMBER 307



Electronic surge arrestor employing Sylvania's SG-1360 spark gap.

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NEW CAPABILITIES IN: ELECTRONIC TUBES • SEMICONDUCTORS • MICROWAVE DEVICES • SPECIAL COMPONENTS • DISPLAY DEVICES

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TITLE ____________________

COMPANY ____________________

ADDRESS ____________________

CITY ____________ STATE ____________

Circle Numbers Corresponding to Product Item

300	301	302	303
304	305	306	307

☐ Please have a Sales Engineer call

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You can also get information using the publication's card elsewhere in this issue. Use of the card shown here will simplify handling and save time.

Breakthrough in performance and price—the facts about a new recorder

A built-in power supply lets you (a) plug it in almost anywhere. AC from 105 to 230 volts, any frequency from 50 to 400 cycles. DC from storage batteries. (b) Uses low-cost 7" reels of ¼" instrumentation tape. (c) High tape-speed stability with a closed loop drive that incorporates a phase-locked capstan servo. (d) Records up to 8 tracks. (e) Direct on each channel to 100 Kc. (f) FM on each channel to 10 Kc. (g) S/N ratios to 40 db. (h) Accepts input signals from 30 mV to 10 V for full scale deflection. (i) Complete, switchable channel electronics, Direct and FM, record and playback, in a plug-in module. (j) Start with one channel if you wish—add more at any time. (k) Record and playback in either direction. (l) Electronic control logic prevents tape damage by operator error. (m) Three tape speeds in the ratio of 1 to 10 to 100—use the decimal system in your calculations. (n) Switching recorder speeds automatically switches the electronics. (o) Dynamic braking. (p) In a portable case, or rack mount with a simple adapter.

Also available, options that include a loop adapter, remote control, and built-in calibration.

Some of these features are not available on any other recorder at any price, yet the PI-6100 sells for less than half the price of most other data recorders. Get the detailed story, and complete specifications from Precision Instrument Company, 3170 Porter Drive, Palo Alto, Calif.

Circle 27 on reader service card

Filling two gaps . . .

RF POWER AT LOW VOLTAGE AND HIGH POWER AT HIGH FREQUENCIES

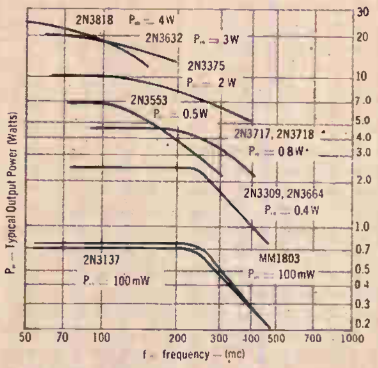
Designed for power handling, the 2N3717 NPN silicon large signal amplifier in a TO-39 package answers the need for power output at low voltage. Operating directly from a 13.6 volt battery source, it will provide 2 watts output at 175 mc with a power gain of 7 db minimum. At 250 mc this same device will provide 4 watts with 7.5 db gain from a 25 volt source. Try the 2N3717 (or its companion — the 2N3718 in the Motorola 102 stud package with leads electrically isolated from the stud) for any of your Class C amplifier requirements — up to 500 mc.

. . . AT THE HIGH END OF THE POWER SCALE

The 2N3818 provides a typical power output of 18 watts at 100 mc with a power gain of 6.5 db, operating from 25 volts. Other devices, as shown by the curves, fill in the power-frequency area to provide optimum performance at various levels.

NPN silicon annular amplifier transistor (2N3818) provides 18 watts output power @ 100 mc using 25 volt source.

You can select the RF transistor that meets your power/frequency requirements.



. . . other new NPN devices for Class C applications are:

Type	Typical Output Power (watts)	Power Gain (db)	Frequency (mc)	Supply (V_{CE}) (volts)	Price 100-Up
2N3309	2.5	7.4	250	25	$12.00
2N3664	2.5	7.4	250	25	14.00
2N3137	0.70	7.7	250	20	7.40
MM1803	0.76	8.5	250	20	7.00

. . . for higher power:

Type	Typical Output Power (watts)	Power Gain (db)	Frequency (mc)	Supply (V_{CE}) (volts)	Price 100-Up
2N3818	18	6.5	100	25	$30.00
2N3632	10	5.5	250	38	33.00
2N3375	7.0	5.4	250	28	22.00
2N3553	4.2	10.0	175	28	7.70

New Motorola Annular† Devices Extend
Require RF Power, Low-Noise, High-Input

LOOKING FOR A LOW-NOISE TRANSISTOR... FOR LOW-LEVEL OPERATION...AT A LOW PRICE?

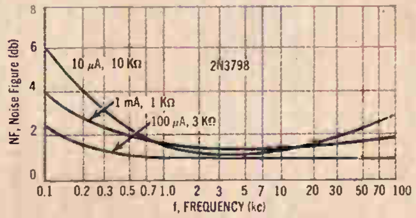
The 2N3798-99, with 0.8 db typical noise figure at 1 kc to 10 kc (see curves) at μA level are highly recommended. And note from the specs below that you don't sacrifice such key parameters as gain and voltage.

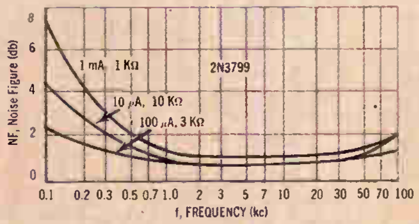
Just as important is the price — $4.10 for the 2N3798 and $4.50 for the 2N3799 in 100-up quantities.

ALSO AVAILABLE — TWO IN A PACKAGE . . . as the 2N3800 thru 2N3811 series Twin* transistors with V_{BE} matched from 10 μA to 10 mA and base voltage differential change specified as low as 10 μV/°C from −55 to +125°C. Units range in price from $9.50 to $18.50 for the tightest matched pairs.

Electrical Characteristics	2N3798	2N3799
Typical Noise Figure (I_C = 100 μA, V_{CE} = 10 V, R_G = 3 K, f = 10 kc)	1.0 db	0.8 db
Collector-Emitter Breakdown Voltage (BV_{CEO}) (I_C = 10 mAdc, I_B = 0)	60 min.	60 min.
DC Forward Current Transfer Ratio (h_{FE}) (I_C = 1 μAdc, V_{CE} = 5 Vdc) (I_C = 10 μAdc, V_{CE} = 5 Vdc)	— 100 min.	75 min. 225 min.
Output capacitance (C_{ob}) (V_{CB} = 5 Vdc, I_E = 0, f = 100 kc)	4 pf max.	4 pf max.

Typical noise figure performance of new low-level 2N3798-99 transistors





*Trademark of Motorola Inc. †Patents Pending

FOR HARD-TO-SOLVE SOLID-STATE CIRCUIT PROBLEMS— INVESTIGATE THESE MOTOROLA FET's

If you've kept up with the state-of-the-art, you know that field effect transistors are gaining rapid industry-wide acceptance in solid-state circuits where performance with conventional junction transistors imposes severe compromises. But maybe you've been too busy trying to solve your circuit problems with conventional means to investigate the newest methods. If so, we suggest that you might *save* time, and develop a superior design, by investigating what FET's can do.

Simply, FET's combine the best features of vacuum tubes — extremely high input impedance, excellent AGC action, etc. — with the best features of semiconductor devices — high reliability, low-power consumption, small size and weight, etc. And, while we don't recommend them for every circuit stage, there are many jobs that they can do better (and cheaper) than either the tube or the junction transistor.

Now Motorola offers you a choice of two FET designs — an insulated-gate FET (IGFET) designed for audio applications, and junction FETs (Junction-FET) for both audio and RF circuits to 100 mc.

Motorola 2N3796-97 insulated-gate FET's operate in both enhancement and depletion modes.

The MM2090-1-2 FET's offer independent gate connections for use in a broader range of applications.

. . . N-CHANNEL JUNCTION-TYPE FET's

The MM2090, 2091, 2092 Junction FET's are unique devices in that each has 2 gates (corresponding to the grids in a vacuum tube) which are brought out to separate terminals. Connect them together and you get extremely high gain ($|y_{fs}|$ = to 3600 μmhos); use them independently and you get excellent high frequency and mixer performance. Even at 100 mc the maximum available gain (mag) is 11.3 db. In addition, you'll find it superior because of low-noise figure and high-input impedance.

ELECTRICAL CHARACTERISTICS						
Type	BV_{GSS} (min.) Vdc	$\lvert y_{fs}\rvert$ μmhos V_{DS} = 10 V, V_{G1S} = V_{G2S} = 0		I_{DSS} mAdc		100-Up Price
		min/max*	min/max**	min.	max.	
MM2090	50	250/1000	500/1500	0.2	2.0	3.50
MM2091	50	400/1600	800/2400	1.5	4.5	4.50
MM2092	50	600/2700	1200/3600	3.0	9.0	5.50

*Gate 2 Common to Source **Gate 2 Common to Gate 1

. . . N-CHANNEL INSULATED GATE FET's

Unlike the junction FET, whose gates must be reverse biased, this insulated gate device can operate with both positive (enhancement mode) and negative (depletion mode) gate-to-source voltages. Depending on the operating point, it can provide extremely high gain or large signal-handling capability. Designed for low-power applications at audio frequencies, it has an input resistance greater than 10^{15} ohms, a typical forward transfer admittance up to 3000 μmhos, and a noise figure typically as low as 3 db.

ELECTRICAL CHARACTERISTICS						
Type	BV_{DSX} (min.) Vdc	$\lvert y_{fs}\rvert$		I_{DSS}		100-Up Price
		(@ V_{DS} = 10 V, V_{GS} = 0)				
		min.	max.	min.	max.	
2N3796	25	900 μmhos	1800 μmhos	0.5 mA	3 mA	$ 9.00
2N3797	20	1500 μmhos	3000 μmhos	2.0 mA	6 mA	11.00

Typical AGC amplifier using Motorola MM2092 junction field effect transistor

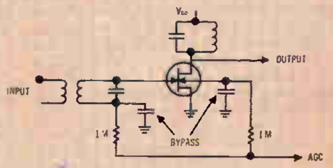


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Photo shows comparative size of new Motorola 70-mil ceramic package (left) and standard TO-18.

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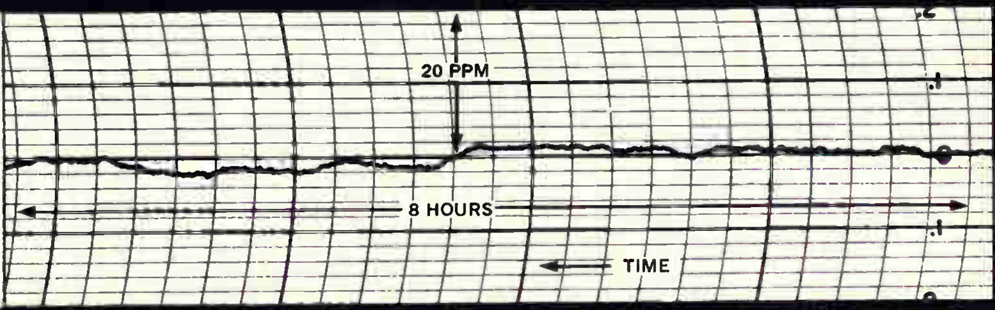

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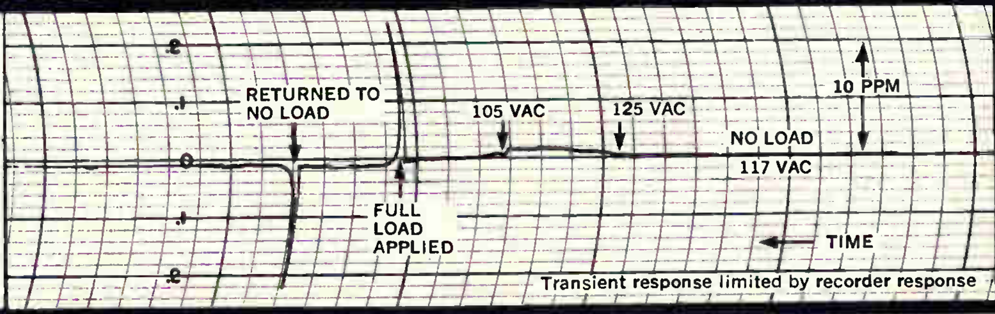

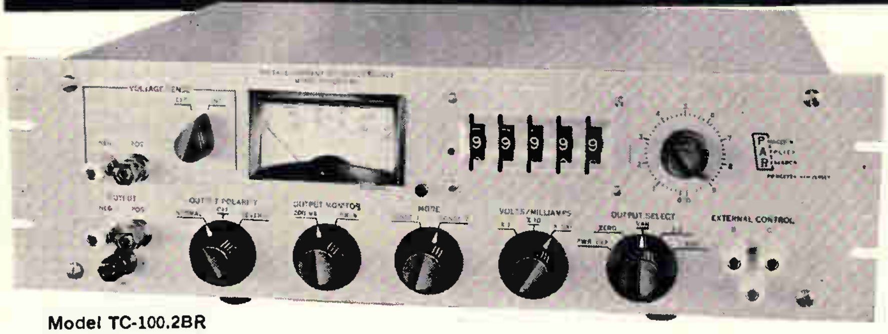

Model TC-100.2BR

Princeton Applied Research Corporation offers a sophisticated line of power supplies providing extremely stable voltage and current outputs whose accuracy is traceable to N.B.S. All models are completely solid state and feature a careful, conservative design leading to highly reliable operation. Indicative of the features found in these units is a unique chopper-stabilized amplifier with a DC open-loop gain of 5 x 10^6, falling off no faster than 6 db/octave to unity gain. This insures extremely low output impedance (less than 10 micro-ohms at DC) and fast transient response without ringing.

PAR Reference Sources permit considerable operational flexibility, having been used in such diverse applications as serving as the reference voltage in analog computers to providing the constant current required in "bucking" coils in elaborate magnetometer systems. All units feature digital output selectors, complete short circuit protection, and low ripple and noise. Write for Bulletin No. 112.

INDEX OF PAR REFERENCE SOURCES

MODEL NO.	OUTPUTS CONST. V.	OUTPUTS CONST. I.	ACCURACY CONST. V.	ACCURACY CONST. I.	RESOLUTION CONST. V.	RESOLUTION CONST. I.	8 HOUR STABILITY CONST. V.	8 HOUR STABILITY CONST. I.	PRICE
TC-602R	0 to 60 V @ 2 A max.	0 to 2 A @ 51 V max. (Requires Ext. Resistors)	0.1% of F. S.	Determined by Ext. Resistors	10 mv	Determined by Ext. Resistors 400 μa max.	.001%	.001% ± stability of external resistors	$1,185.
TC-100.2R	0 to 100 V @ 200 ma max.	0 to 100 ma* @ 100 V max.	0.01% of F. S.	0.02% of F. S.	1 mv	1 μa	.001%	.002%	$1,500.
TC-602CR	0 to 6 V 0 to 60 V @ 2 A max.	0 to 60 ma 0 to 600 ma 0 to 2 A @ 60 V max.	0.01% of F. S.	0.03% of F. S.	1 μv min.	10 m μa min.	.001%	.002%	$1,750.
TC-100.2AR	0 to 100 V 0 to 10 V 0 to 1 V @ 200 ma max.	0 to 100 ma* 0 to 10 ma 0 to 1 ma @ 100 V max.	0.01%	0.02%	10 μv min.	10 m μa min.	.001%	.002%	$1,800.
TC-100.2BR	0 to 100 V 0 to 10 V 0 to 1 V @ 200 ma max.	0 to 100 ma* 0 to 10 ma 0 to 1 ma @ 100 V max.	0.01%	0.02%	100 m μv min.	100 μ μa min.	.001%	.001%	$2,200.
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*Available to 200 ma (at extra charge).

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June 28, 1965

Electronics Review

Volume 38
Number 13

Military electronics

Blueprint for the 70's

The conversion of an experimental outfit at Fort Benning, Ga., into the Army's first air-mobile division will provide the electronics industry with a fairly clear blueprint for the equipment to be used by the Army of the 1970's.

The new 1st Cavalry Division (Air Mobility) has been tested since Feb. 15, 1963, as the 11th Air Assault Division (Test). It will be able to move men and equipment directly to a battle area by air instead of truck or on foot. It will also use helicopters as weapons platforms instead of tanks.

Fighting unit of the Army's new air-mobile division prepares to board helicopter.

Housekeepers. Industry, which moved in and set up housekeeping around Fort Benning the day the Air Assault Division was formed, knew that any equipment the air division selected would probably become standard equipment for all Army divisions, whether they operate in the air or on the ground. If equipment is better and smaller—the first two goals the signal battalion of the 11th Division set out to achieve—ground divisions will want it, too.

Given equipment used by paratroopers, the signal battalion got rid of all 2½-ton trucks and cut the number of ¾-ton trucks down from 64 to seven, none of which carries electronic equipment. By redesign, reconfiguration, or by buying new gear, it put all electronic equipment on quarter-ton vehicles.

Almost all of the new division's 434 aircraft are helicopters. At present, Army helicopters have almost no navigation equipment; they need an accurate system to navigate to small areas. They need station-keeping equipment for flying in formation during bad weather and at night. Lights have been tried, but the obvious disadvantages have made the Army look favorably at a radar transponder system developed by Lockheed-Georgia Co., a division of the Lockheed Aircraft Corp.

Skip zone. Helicopters also need communications for a skip zone between 50 and 75 miles. F-m works well up to 50 miles, and high frequency and single-sideband beyond 75. In between, there is too often silence.

Other avionics needs of the new division include:

- A visual readout on f-m homing and position-fixing equipment. Helicopters now home in aurally on an f-m radio, if the key is held down by the operator; a visual readout would be more precise.
- A scrambler system for every f-m radio. Sanders Associates, Inc., is working on one that uses a plastic coded key card on the transmitter and an identical one on the receiver.
- A good low-frequency portable homing beacon.

The new division would also like a power supply that provides 2.5 to 3 kilowatts at 115 volts, weighs no more than 70 pounds and operates on an engine that can use several different fuels.

Technical support

Under the dual pressure of an economy drive and a Civil Service Commission ruling, the Defense Department is about to reduce sharply the number of contractor-furnished experts who perform technical support service for the military. The work will be turned over to Civil Service employees and to the military itself.

The curtailment will affect about 7,000 contractor personnel who train government workers to operate and maintain weapons and other systems or who do the work themselves on a for-hire basis. It will not change the number or status of the so-called tech reps, who operate as liaison men between contractors and the military.

To the defense industry, the change will mean loss of about $117 million of government business a year. Exactly what the effect will be on defense contractors generally, and on the electronics industry specifically, can't be determined until the military furnishes detailed plans for the conversion.

Against the law. The decision to convert most technical support work to an in-house effort stems from a study ordered last September by Defense Secretary Robert S. McNamara. The Secretary acted after congressional committees and the General Accounting Office alleged that use of these specialists was often uneconomical and that it also appeared to violate Civil Service regulations.

In February, the Civil Service Commission ruled that such employment is illegal where contractor personnel work directly under the supervision of a federal employee who not only controls their work and judges its quality, but also has the power to remove them from a government project.

The action will aim first at eliminating this illegal employment. But it will also be directed in areas where the military concludes that government personnel can perform the work of contractor employees at a lower cost, and where it appears that military preparedness could be improved.

The study ordered by McNamara determined that 160,000 defense employees have skills comparable to those of the contractor's technical support personnel and that their employment, including fringe benefits and administrative costs, as well as salaries, costs about $2,630 less per man per year.

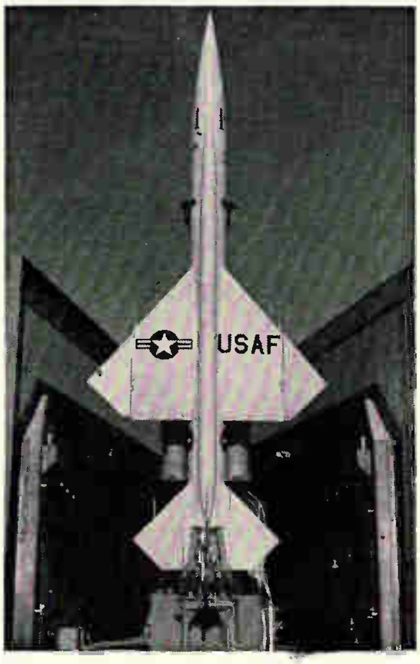
No pirating. What will happen to the contractor's employees is not clear. Some may switch to government service, but Robert C. Moot, acting deputy assistant defense secretary for logistics service, declares that the Pentagon will have no program to pirate them.

The study group, which Moot heads, is also looking into conversion of other military support—mainly housekeeping services for military bases—to an in-house effort and is investigating whether defense contractors should lease or purchase electronic data-processing equipment.

Moot said the study group is convinced that contractors should be buying most of it as a means of lowering costs to the government. He disagreed with the GAO's recommendation that the government itself buy data-processing equipment and make it available to the defense contractors for a price.

Converted killer

What good are obsolete missiles? The jet-powered, ground-to-air Bomarc A, developed in the late 1950's, was replaced two years ago; now the Air Force has a plan to use 234 of the leftovers. It will shoot them down.



Bomarc A poised for flight.

Sometime this October, a Bomarc A will be fired at more than twice the speed of sound toward a group of fighters equipped with air-to-air missiles. The needle-nosed killer, converted into a victim, will be a drone. Missilemen will also get a chance to test the second generation Bomarc B on some of the birds, and others will be turned over to the Navy.

The changeover. Conversion from hunter to hunted required a change in the bird's electronics. One Bomarc A has already been shot down at 55,000 feet in a test over the Gulf of Mexico; but in case an attack missile misses, the Air Force wants to know by how much. The drone will need a miss-distance system; for redundancy, the Air Force is installing two.

One, a bi-doppler scoring system called Bidops, has an accuracy of three to five feet. It consists of a unit in the drone, a ground receiver and a quick-readout computer. The drone transmits two carrier frequencies and receives two from the plane and the air-to-air missile, compares their phase and transmits the information to the ground station, where it is processed into the distance by which the attack missile missed.

The other system, Matts (multiple airborne target tracking system), consists of transmitters in the drone, the attack missile and the plane. Two ground stations, picking up three signals, can determine by triangulation the miss-distance range to within 50 to 75 feet.

On target. During its power phase, the drone will be tracked by an AN/FPS-16 radar. Early plans to use the Sage computer control system to guide the missile were dropped because of the high cost—$1,000 an hour. In its place, a computer fashioned out of spare parts, costing less than $200, was made at Hurlburt Field, Florida.

To assist radar tracking, the missile is being equipped with a radar reflector, a Luneberg lens, and a beacon transponder. To protect populated areas if the drone should get out of control, two destruct systems are being installed. Either one can be activated through the beacon transponder or the regular guidance command system.

Computers

Model solution

An engineer designing a direct digital control (DDC) system to automate a production line generally can't tinker with the line itself; a chemical company, for example, simply can't tie up a multimillion-dollar plant for a few weeks.

Lacking a factory, the designer has to base his calculations on estimates and simulated results. And since a customer is more likely to buy a DDC system he can see in operation, the computer maker may find that the inability to give a real demonstration costs him money.

No products. The International Business Machines Corp. has come up with a Mahomet-and-the-mountain solution: it's building a model plant. The facility, about twice the size of a two-car garage, is nearing completion at San Jose, Calif. Although it won't produce anything, it will serve as a working model of a distillation plant; distillation processes are common to most petroleum and chemical plants. Engineers will have an opportunity to experiment with some new control techniques and test some old ones.

To further assist in designing DDC systems, IBM's industrial psychologists and human factors experts will work with the computer engineers to make the system easy to operate by the customer's production workers.

In many cases, production processes can be simulated mathematically, but IBM says that it generally isn't possible to simulate such problems as process noise and disturbances. In addition, DDC systems usually run into trouble during the early debugging stages. Controls must be "tuned" for peak efficiency. IBM hopes the model plant will provide enough production know-how so that its engineers can tune a distillation process automatically.

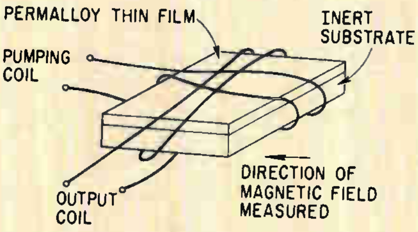
IBM also hopes to learn what to do if the computer fails. In most cases, customers demand that some provision must be made to keep the production line operating even if the computer breaks down: this could involve manual control and some semiautomatic system that could back up the computer until repairs can be made.

Instrumentation

Thin magnetometer

When thin-film specialists at the Lockheed Aircraft Corp.'s Microsystems division began investigating magnetic materials about two years ago, they discovered a combination that could replace the bulky core of a flux-gate magnetometer with a thin wafer. A laboratory model of a microminiaturized instrument built a couple of months ago has proved, to Lockheed's surprise, to be more sensitive than a conventional magnetometer, and responsive to a much wider band of frequencies as well.

Though Lockheed engineers are still experimenting with the instrument, they have already found it a handy device for several applications—from sensing the presence of automobiles and distinguishing between different models, to measuring the current in a wire without breaking into the wire.



Thin-film magnetometer is built on wafer-thin substrate and measures only about a half-inch square.

Thin and sensitive. The smallest conventional flux-gate magnetometers measure three inches in diameter by three inches in length, but their sensitivity is only 10 microvolts per gamma (the unit of magnetic force). The Lockheed instrument, on the other hand, is wafer-thin and measures only about a half-inch square, yet its sensitivity is two millivolts per gamma. And the bandwidth of the thin instrument is in the several-megacycle range, compared with only about five kilocycles for the bulkier units.

Although Lockheed is understood to be negotiating with several manufacturers for the production of the instrument, the company declines to say which applications are under discussion or which companies are discussing them.

In general, the principle behind the thin-film magnetometer is the same as in the conventional instruments. But instead of using a relatively bulky magnetic core in the center of the unit, the Lockheed model contains a thin inert substrate on which a layer of Permalloy 2,000 angstroms thick is deposited. To measure an electromagnetic field, an a-c voltage is developed across an output coil. The frequency of that voltage is harmonically related to the frequency of the input, or pumping current, and the amplitude of the voltage is proportional to the flux of the magnetic field being measured.

Under the ground. One of the early experiments indicated a possible use in traffic control systems for the instrument. Lockheed engineers buried it in the ground, and attached it to nearby readout equipment. When different cars passed over the instrument, it picked up their particular electromagnetic signatures. The instrument could distinguish a Chevrolet from a Volkswagen. Snow or ice on the ground would not affect the unit's performance, the engineers say.

A more intriguing possibility for the electronics engineer is the use of the instrument to detect the faulty operation of electronic equipment, although Lockheed engineers say investigation hasn't progressed far enough to determine the feasibility of this application. To see if a fault existed, the engineer would compare the signature of the equipment with its standard signature, established earlier. Thus, the check could be made without plugging into the component.

Space electronics

Blame it on the glitch

Computer experts at International Business Machines Corp.'s Space Guidance Center at Owego, N.Y., worked their midget space computer round the clock in an attempt to find out why it failed during Gemini 4's space flight early this month.

"We know this much," a puzzled and tired IBM technician said: "something went wrong in the computer's memory. But memories don't just flop; something must cause them to flop. What it was—we don't know."

After the extensive tests, the computer was shipped to Cape Kennedy, where it was put back into the Gemini spacecraft's inertial guidance system for further examinations.

There has been speculation that the failure was caused by a "glitch"—slang for a power surge which could disrupt the memory.

Piece by piece. For the past week and a half, engineers have been operating the 59-pound instrument in various ways and under various conditions; but so far, even when the computer was run in a vacuum, there has been no indication of what went wrong. It has even been taken apart and examined, piece by piece.

The teams conducting the tests are made up of engineers from IBM, the National Aeronautics and Space Administration and the McDonnell Aircraft Corp., which is prime contractor for the Gemini spaceship.

The memory of the computer is a nondestructive readout type, built of two-aperture ferrite cores called MARS, for multiaperture reluctance switch. [Electronics, May 3, p. 71.] In a nondestructive readout memory, the data remains intact in a ferrite tablet with two holes of about equal size; the two holes provide three legs for flux paths. The memory was designed to hold 4,096 39-bit words.

The instrument was to assist the astronauts in stabilizing the craft during its 62 orbits and it was to assist in steering the ship into its critical reentry path.

Consumer electronics

Computer tutor

An engineer facing the problem of keeping up with rapidly changing technology may soon get some help from a computer miles away.

To determine whether complex technical material can be taught effectively by computer assisted instruction, the International Business Machines Corp. is giving a course in computer logic to 100 of its engineers in four cities.

The course uses the IBM 1050 data communications terminals linked by telephone line to a 1440 computer in Poughkeepsie, N. Y., on which the course is stored. Remote computer assisted instruction is also in the experimental stage at several universities, including the University of Michigan, Florida State University and Pennsylvania State University.

The IBM teaching system will include two visual units something like television screens, which will be used in only two of the cities. They will display graphic material in addition to the typewritten information on the 1050 terminal. The computer can command each visual unit to display any one of 256 microfilmed images in one second. New microfilm cartridges may be substituted manually. In the two other cities, graphic material will be printed in books. A comparison of results will determine the efficiency of the automatic visual display.

New language. Instructors, using the same 1050 terminals, can program the computers with a language developed by IBM, called Coursewriter. Coursewriter enables teachers with no computer training to enter instructional material into the computer. The instructor identifies the text and questions and answers that he types on the 1050 with a code word.

In a typical lesson, the student starts by typing his name and the name of the course. The computer then automatically begins where the student had stopped in the preceding lesson. The computer presents text material or a reading assignment to the student and poses questions. The student's answer will determine which of several instructional paths the computer will take.

Grades. The computer also grades each student and reports weak points in the lesson to the instructor by noting the questions most often answered wrong.

Up to 12 terminals may be connected to a 1400 series computer for time-sharing operation. Experiments have shown that two students working together on one terminal do well as one working alone, so that a class of 24 students may be taught by machine at one time.

Management

Poor man's PERT

Like project managers everywhere, Maxime G. Kaufman, an electronics engineer at the Naval Research Laboratory in Washington, had a problem: too much to keep track of. His workload wasn't heavy enough to warrant the use of a computer to keep pace with the hundreds of activities that made up his project—a space surveillance job—so he designed what in effect is a poor man's PERT.

PERT, an acronym for performance evaluation review technique, and a computer are used to plan, evaluate and diagram the progress of a complex project, and show possible snags in the work schedule. First used in the Navy's Polaris program, it has since become a popular management technique.

In Kaufman's PERT system, many different colored lights, each representing a various part of the over-all project, are wired to what looks like a large tote board. By following the arrangement of the lights, the project manager can keep tabs on the progress of each of the interrelated jobs. The board can be updated by changing the wiring on the back of the board.

Who's doing what? Kaufman's area of the lab is the post-detection section of the space surveillance branch, applications research division. The section is working on four main electronics projects, destined for installation at nine places. Since each project may be involved with 24 different activities—such as administrative, design, supply, shipping and installation — there are 864 possible work situations.

Section-eye view. The board is

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Circle 35 on reader service card

basically an NRL organization chart as viewed from Kaufman's section. Most of it is taken up by squares indicating the 24 activities and lines indicating work flow. Under each square are four colored lights, each color indicating a project. The color key is given in the upper right corner of the board.

The nine sites are listed along the bottom of the board. When a selector switch is turned to the appropriate site number, the site is identified by a pilot light. At the same time, the whereabouts of each project is identified as a colored bulb lights up under the appropriate activity square. The next turn of the selector switch shows the status of the equipment destined for yet another site.

To keep the board up to date, the group leader for each project changes the wiring on the back of the board. The board is hinged for access to the wiring and fitted with numbered terminals and colored wiring so changes can be made quickly. The board has a clear plastic overlay, on which notes can be written in grease pencil—for example, the delays expected at each activity could be jotted down and added up to determine the sequence of activities taking the longest time.

Better boards. Kaufman says the same general approach was first tried with colored pins, rather than lights, but too many pins had to be used. The resulting diagram was too confusing and the pins were difficult to see at some viewing angles.

Kaufman plans to improve the lighted boards. He would like to see the light patterns changed with a patchboard, rather than with the wiring behind the board. And he thinks that if all sections in a lab branch were equipped with boards, the head of the branch could be supplied with a master board.

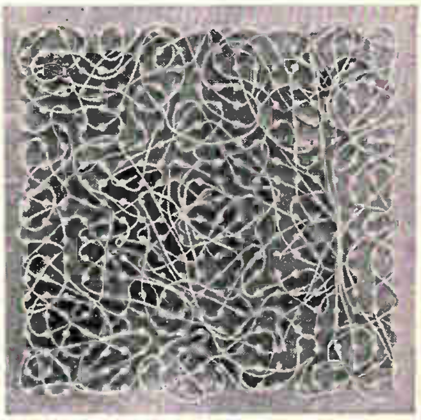
Manufacturing

Back to backplanes

When electronic equipment requires the interconnection of large numbers of microcircuits, most manufacturers save space and money by using mass-produced multi-layer printed circuit boards. But at least one developer is going back to backplanes with discrete point-to-point wiring for systems that require frequent and extensive design changes on one-of-a-kind assemblies—such as in space vehicles, where bulk is a major problem.

The Jet Propulsion Laboratory of the California Institute of Technology is developing backplanes that are microminiaturized versions of the ones frequently seen in computers and other large systems. JPL's backplanes will be made with welded 34-gauge magnet wire, with conductors only 0.0063-inch thick and with 0.001-inch thick insulation.

Full circle. Conventional backplanes consist of an array of terminal pins, which are joined by in-



Backplane, wired with single strand of magnet wire, has 400 discrete interconnections, measures one square inch.

sulated wires whose stripped ends are tightly wrapped, soldered or welded to the pins. When fully wired, a backplane looks like a field of organized spaghetti. It is usually an inch or more thick and may be several feet square.

The new magnet wire planes, which were shown this month at the National Electronic Packaging and Production Conference in Long Beach, Calif., provide the high density of wiring that microcircuitry requires and much the same design flexibility as conventional backplanes. The planes are very thin because the wires are welded to terminals that are almost flush with the board.

Leonard Katzin of JPL developed the design; he points out that one of the major attractions of magnet wire is its high reliability. Magnet wire has been used for many years in electronic components. To illustrate design flexibility, he showed a one-inch square plane with 400 terminals with 0.050-inch center-to-center spacing, which is the lead spacing on integrated circuit flatpacks. The photo on page 36 shows a backplane wired in a test pattern made from a single, randomly routed strand of magnet wire. The wire is insulated with Formvar and can be welded without stripping off the insulation. The heat and pressure of the weld operation removes the insulation at each welded joint.

The wire-routing and welding process can be done mechanically, Katzin said, by guiding a pantograph over a large pattern or by using tape-controlled wire feeders and welders.

Stick modules. The welded planes are to be used in a new version of a standardized module design that JPL has developed. The wiring goes on the back of a molded plastic board with terminal pins connecting front and back surfaces. The leads of up to 15 flatpacks are welded to the pins on the front of the board. In the original module design, 32-gauge magnet wire, insulated with polyurethane, is routed from pin-to-pin on the back of the board. The wire is soldered with a hand iron, which also strips off the insulation at each joint.

Communications

Sour note

The international harmony that greeted the successful launching of Early Bird has degenerated into squawks over charges for its use. This month, the Communications Satellite Corp., Early Bird's keeper, was faced with the possibility that early enthusiasm over the satellite might be cooled by the cost.

Initially, Comsat was swamped with requests for Early Bird channels. During the test period in June, the United States made only a nominal $365-per-hour ground service charge on tv use of Early Bird. But its overseas partners levied a ground station charge of $110 a minute for receiving programs, then changed the rate to a fixed fee of $1,000 plus $30 per minute.

Reversal sought. Washington speculation is that the FCC will give at least temporary approval to Comsat's rate application, and will permit only Comsat to lease tv channels until a decision is made on what services carriers will be allowed to offer. Comsat itself has delayed until late fall a decision on how private users will apply the channels they lease. In the meantime, it will hold an inquiry.

A 'misunderstanding.' The British aggravated the issue when they slapped on a charge of $6,720 per hour for use of the Goonhilly Downs ground station. When the tv networks retaliated with a boycott, the British backed down and reduced the charge to $2,800 per hour. It was all a "misunderstanding," they said. What their eventual commercial rate will be is still not known.

Comsat itself recently filed its proposed rates with the Federal Communications Commission. For one-way transmission in nonpeak hours (5 a.m. to 8 a.m. and 2 p.m. to 9 p.m., New York time), it wants $2,400 for the first half-hour and $475 for each immediately succeeding 15 minutes. Broadcasters immediately called those rates too high. They fear that European rates will be even higher.

The FCC faces opposition on its ruling that Comsat will have temporary control of the first three U. S. ground stations. The American Telephone & Telegraph Co. and the International Telephone and Telegraph Corp. have asked the FCC to reverse itself. ITT called the award monopolistic, and AT&T contended that giving the stations to Comsat was not in the public interest.

Budget

A slap and a cut

Still intent on showing the Pentagon who's boss, the House Appropriations Committee has shaved $100 million in electronics funds from the fiscal 1966 budget and suggested that Defense Secretary Robert S. McNamara won't miss it if he improves his management and procurement policies.

The committee authorized a budget of $45 billion, $2.5 billion below the figure for fiscal 1965, which included an extra $700 million for the war in Vietnam. The panel acknowledged that it might eventually have to raise the new budget also.

If the reductions stand, they will affect such research and development projects as the Navy's Integrated Light Attack Avionics System (ILAAS), the Air Force's Short Range Attack Missile (SRAM) and the Navy's Advanced Surface-to-Air Missile (ASM). They will also apply to procurement of electronics equipment already in production, principally items not components of aircraft, missiles or ships.

Unwanted bonus. The committee's reductions in these and other programs recommended by McNamara were partially offset, however, by funding for new and additional weaponry the defense chief did not seek. The committee recommended an extra $7 million to speed development of a new manned bomber, an extra $134 million to procure six instead of four nuclear attack submarines, and $20 million for procurement of long-lead-time items for a nuclear-powered guided missile frigate. (Not all of the additional funds, or the deletions detailed below, are for electronics.)

The net reduction in McNamara's budget request is thus only $60 million. Congress probably will stick closely to what the committee recommends.

The committee cut $27 million from the $927 million sought for procurement of new electronics and communications systems not associated with specific aircraft, missiles or ships. It said that though the Pentagon has made some progress in improving management and procurement practices, its own investigations and those of the General Accounting Office still show room for major improvement. It urged more competitive procurement and suggested combining similar equipment needs of individual services into a single procurement package.

High cost of talk. The committee chopped $12 million from the $407 million sought for operation and maintenance of communications equipment. The effect of this is to hold Army and Navy requests to the level of the present fiscal year.

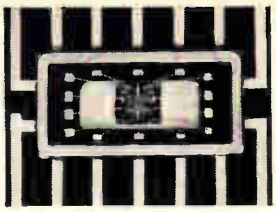
Two major aircraft programs suffered cuts. The committee dropped $18 million from procurement funds for the F-111 fighter-bomber, and $26 million from funds for avionics and spare parts for the F-4 fighter. The aim: to encourage more competitive procurement.

The committee deleted $4 million from the ILAAS program because it feels the program has not been coordinated with the integrated helicopter avionics system (IHAS) development and the Mark II avionics system being developed for the Air Force version of the F-111.

The reduction for the Navy's ASM amounts to $10 million. This missile is considered a long-range replacement for the existing Typhon missile, which has been plagued with technical problems.

Go, but slow. The committee said it cut the SRAM missile request by $31 million because the program has been delayed and its objectives are being revised. The delay means that the project-definition phase cannot be completed in the coming fiscal year, and that not as much money will be required.

Results wanted. The committee also criticized McNamara for not putting enough new weapons systems into the hands of troops. Considering the billions spent on research and development in recent years, new systems have not been added to the inventory "in sufficient quantity or sufficient quality to justify the massive effort being funded," it said.



TI Series 54 TTL Sets in Saturated Digital

Industry's major source for integrated circuits*— 97 catalog circuits in ten families — offers you high speed with low power dissipation, high noise margin with high fan-out

TYPICAL CHARACTERISTICS Parameter	Basic Gate	Flip-flop
Propagation delay	15 nsec	40 nsec
Power dissipation	10 mw/gate	60 mw
Fan-out	10	10
D-c noise margin	1 v	1 v
Supply voltage	4.5 to 5.5 v	4.5 to 5.5 v
Temperature range	–55 to +125°C	–55 to +125°C

Figure 1. Typical characteristics of Series 54 TTL integrated circuits

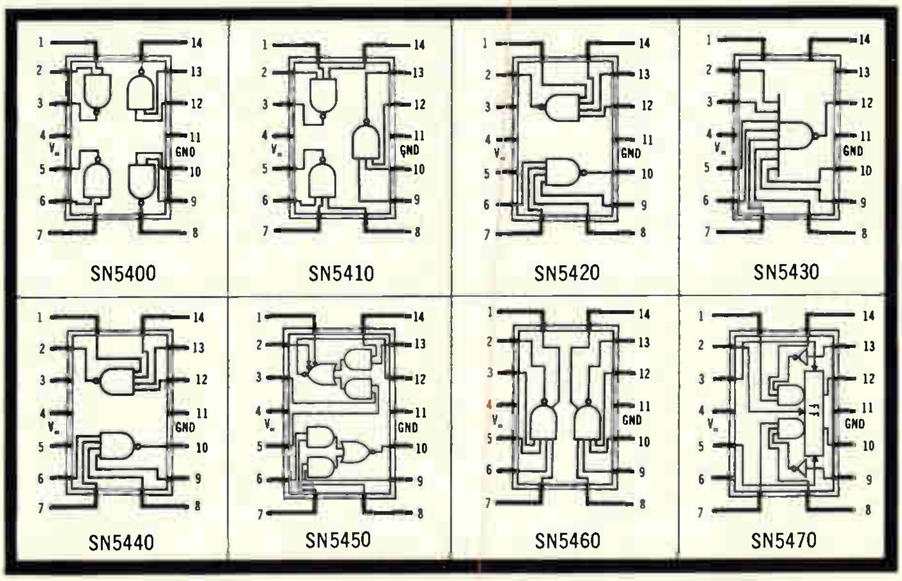


Figure 2. Logic diagrams for Series 54 TTL integrated circuits

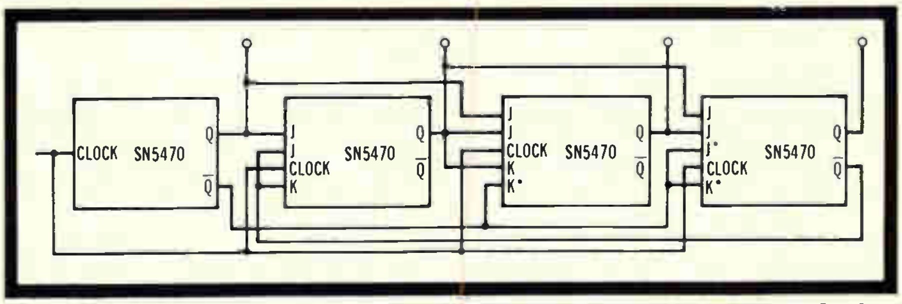


Figure 3. This complete synchronous binary decade counter uses only four SN5470 flip-flops

*Patented by TI

Series 54 optimized circuit design gives you an ideal trade-off between speed (15 nsec) and power dissipation (10mw). High noise margin (typically 1 v) is maintained with full fan-out of 10 for each gate. Fan-out of 30 is available from the power gate.

This unique combination of parameters promises to standardize integrated-circuit usage in applications calling for high-performance saturated logic.

Multi-function circuits for low system cost and improved reliability

In the eight Series 54 networks shown in Fig. 2, TI's multi-function approach to semiconductor-network design and fabrication is used extensively. Up to four circuit functions are built in a single bar of silicon, making possible savings in system cost, weight, and size, while increasing system reliability.

The SN5400, for example, incorporates four 2-input NAND gates in a single package. The SN5450 includes two EXCLUSIVE-OR gates, the equivalent in complexity of six NAND gates. The SN5470 is a clocked J-K flip-flop with two additional inverters in the same structure available for input gating. The synchronous binary decade counter shown in Fig. 3 requires only four SN5470 flip-flops; no auxiliary gates are required.

TTL at its best

Transistor-Transistor Logic (TTL) fully exploits the inherent capabilities of integrated semiconductor structures, and the TI NAND gate circuit shown in Fig. 4 is TTL at its best.

a New Industry Standard
Integrated Circuits

The multiple-emitter transistor input provides a faster turn-off time than other logic forms, thereby minimizing propagation delay. Because of unique circuit characteristics and exacting process control, propagation delays are almost independent of temperature and loading (see Fig. 5).

The output stage of the circuit provides low line-termination impedance in both logical "0" (12 ohms) and logical "1" (100 ohms) states. This contributes to low propagation delays and preserves undistorted waveforms even when driving large-capacitance loads. The low line-termination impedance also accounts for low susceptibility to capacitively coupled noise.

Typical noise margin for Series 54 integrated circuits is one volt. Guaranteed worst-case noise margin is 400 millivolts for both logical "1" and logical "0" conditions, as shown in Fig. 6. This wide margin for ground- and signal-line noise is made possible by the strong overdrive to the output transistor and by the large V_{BE} drops inherent in the small transistor geometry.

eries 54 uses reliable "flat-packs"

'I's standard ¼" by ⅛" flat package s used for all Series 54 networks. This package — proved by more than 35,000,000 hours of controlled tests and four years of field use — features all-welded construction with hermetic glass-to-metal seals. The thin, rectangular configuration and 14 lateral leads make this package suitable either for high-density equipment or for mounted circuit-card assemblies.

For your added convenience, all TI ntegrated circuits — including Series 54—are now shipped at no extra charge n TI's exclusive Mech-Pak carrier. This plastic carrier simplifies handling, and reduces your costs of incoming inspection, testing, breadboarding, storage, and assembly.

Circle 149 on the Reader Service Card for data sheets on Series 54 integrated circuits, or contact your local TI Sales Engineer.

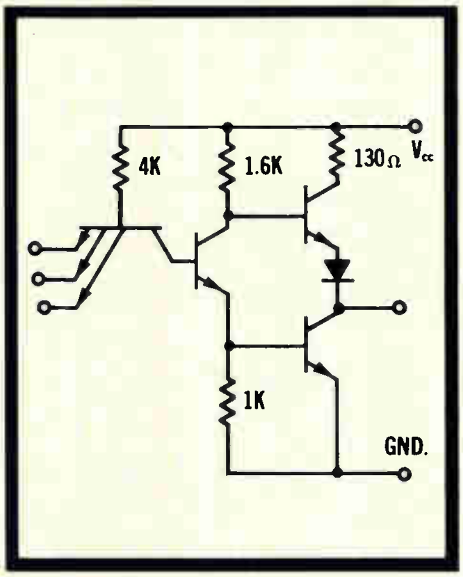


Figure 4. Circuit diagram for basic Series 54 NAND gate

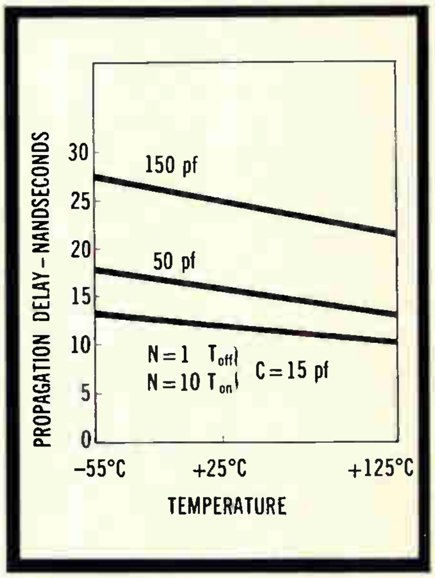


Figure 5. Typical propagation delay vs temperature

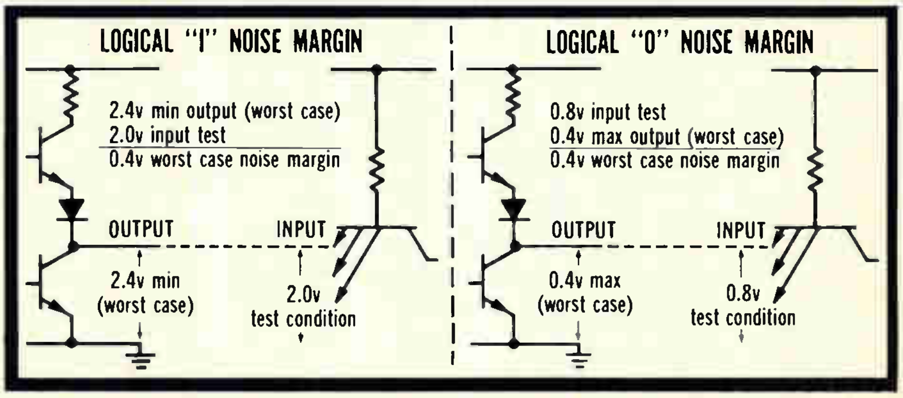


Figure 6. Noise immunity is guaranteed at 400 mv, worst-case, in both logical states

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TEST YOUR KNOWLEDGE
OF THE
STATE OF THE ART
IN
DIFFUSED-ALLOYED AND EPITAXIAL CONTROLLED RECTIFIERS

See answers at bottom of page

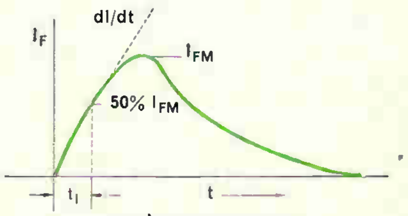
QUESTION 1: More than one process is used in the production of controlled rectifiers to ________________.

A – provide a wide range of characteristics
B – assure lowest over-all cost for each application
C – make possible a trade-off of parameters

International Rectifier manufactures 3, 4, 7, 10, 16, 35, 70, 100 and 150 average ampere controlled rectifiers by the diffused-alloyed process and epitaxial devices rated 35 through 150 average amperes to meet the wide range of applications in industry.

QUESTION 2: The__________method produces devices having fast turn-off and high dI/dt capability at 1000 volts PRV and above.

A – all diffused
B – diffused-alloyed
C – epitaxial

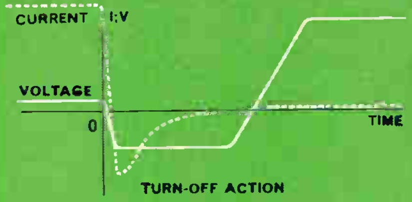


dI/dt TEST WAVE FORM

International Rectifier epitaxial units are available from 600 to 1300 volts PRV in current ratings from 35 to 150 average amperes. Recommended for high speed switching applications.

QUESTION 3: Diffused-alloyed units with gold doped junctions provide__________.

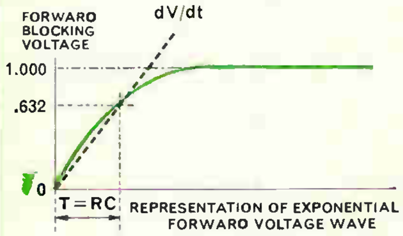
A – low forward voltage drop
B – shortest turn-off time
C – high blocking voltage



Ratings of International Rectifier diffused-alloyed controlled rectifiers range up to 600 volts PRV for 3.0 and 4.7 average ampere units and up to 1000 volts PRV for 10 and 16 average ampere devices with turn-off time down to 12 μ sec. Units also available up to 800 volts PRV in 35 through 150 average ampere ratings with turn-off time down to 20 μ sec. Highly desirable for low voltage inverters.

QUESTION 4: Devices having rated dV/dt of 1000 volts per microsecond are readily obtained from the__________process.

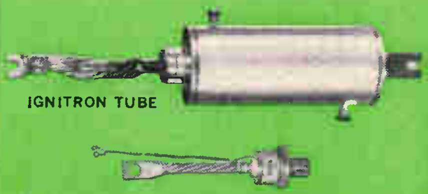
A – epitaxial
B – diffused-alloyed
C – all diffused



International Rectifier epitaxial controlled rectifiers are available with dV/dt greater than 200 V/μ sec. in 35, 70, 100, 150 average ampere types; 1000 V/μ sec. in 35, 70 average ampere types also. Ideal for d.c. motor drives, 50 H.P. and up.

QUESTION 5: The major applications for which diffused-alloyed controlled rectifiers are best suited are________________.

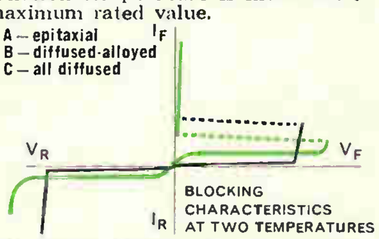
A – d.c. motor drives
B – frequency changer type motor drives
C – thyratron and ignitron tube replacement



International Rectifier's 70 average ampere controlled rectifier package with flexible leads meets JEDEC outline TO-49; International Rectifier's flag type terminal 70 average ampere package meets TO-83.

QUESTION 6: Controlled rectifiers made by the ________________ process *consistently* exhibit increasing reverse avalanche and forward breakover voltage as junction temperature is increased to maximum rated value.

A – epitaxial
B – diffused-alloyed
C – all diffused



International Rectifier epitaxial controlled rectifiers provide highest temperature capability...150°C maximum for 35 and 70 average ampere devices. High temperature operation makes possible substantial reduction in size of equipment in many applications.

QUESTION 7: With International Rectifier's new SCR Calculator you can determine________________.

A – SCR rating and number required
B – R-C imposed dV/dt
C – phase shift range

If you do not yet have this compact time-saving SCR Calculator, send check or money order for $1.00 to International Rectifier Corp., 233 Kansas Street, El Segundo, California.

International Rectifier's broad line of standard devices meets the vast majority of applications and inventories are maintained for fast off-the-shelf service. For special requirements you have at your disposal IR's outstanding research and application capabilities. ■ For further information and application assistance, contact your local International Rectifier sales office or write to 233 Kansas Street, El Segundo, California.

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Answers: 1-A, B and C; 2-C; 3-B; 4-A; 5-A and C; 6-A; 7-A, B and C.

Washington Newsletter

June 28, 1965

Pentagon weighs "TVA's" for research

Wholly owned government corporations are being discussed in the Defense Department as a tool to manage the department's in-house research. The corporations would handle in-house laboratory research and contract support and many of the management and policy-guidance jobs currently performed by nonprofit corporations like the Institute for Defense Analysis, the Aerospace Corp. and the Mitre Corp.

The discussions are still in the preliminary stage; Defense Secretary Robert S. McNamara, while willing to listen, has not yet authorized full-scale feasibility studies.

The corporations, modeled after the Tennessee Valley Authority or the St. Lawrence Seaway Corp., **would give the Pentagon flexibility in personnel policies, so that it could pay above government scales and attract scientists to government;** at the same time, decision-making and guidance responsibilities would remain in the hands of the government. A major criticism of nonprofit corporations has been that they take decision-making out of government hands.

Opposition, perhaps sufficient to scuttle the idea unless McNamara really goes to bat for it, can be expected from the services because of the fragmentation of control the corporation concept contains, as well as from the nonprofit corporations themselves and their partisans in Congress.

Agencies test Transit satellite

The Navy's Transit satellite navigation system is being tested aboard a National Science Foundation ship and a Coast Geodetic Survey vessel to determine what value it may have for commercial nonmilitary governmental use. A panel of representatives from the National Space and Aeronautics Administration, the Commerce, Treasury, Defense and Interior Departments, and the Federal Aviation Agency will get the results and issue a report by December.

The system would provide navigational data and traffic control for commercial shipping, oceanographic and Coast Guard vessels, and aircraft. Results of Navy tests scheduled to begin within a month will go to the committee also. The Navy will investigate aircraft applications. It still has not completed evaluation of the shipboard equipment for use with the three or more satellites in the Transit system.

Navy to test island Spadats

Two Navy Research Laboratory stations to test methods suitable for island installations of the Space Detection and Tracking System (Spadats) will be opened in south Texas late this summer or in early fall. The United States currently has no special system for island-based detection; **the coming tests suggest that the Pentagon may be planning to put stations closer to the equator, where they can track and monitor more foreign satellites.**

The test stations, which will work on detection and ranging methods, will be at Roma and Raymondville.

The Navy is spending $10 million on modifications for its part of the Spadats system. It is converting 108-megacycle equipment to 216 Mc, for better low-altitude coverage and high-altitude detection, and building receiving stations at Lewisville, Ark., and Hawkinsville, Ga.

Washington Newsletter

House defies LBJ on one arms bill . . .

The $1.9-billion military construction bill has become a focal point for a constitutional dispute between Congress and President Johnson. The bill authorizes new construction to support a wide range of military systems heavily dependent upon electronics—including $24 million worth of facilities for the Nike X antimissile system, $35 million for continental air defense, $35 million for missile test ranges and $62 million for communications, navigational aids and detection systems.

The threat of a presidential veto hangs over the bill because the House included a provision that would give Congress authority to review and reject any plan by the Pentagon to close a military base. The President has already vetoed two bills with such provisions, to defend against congressional encroachment on his powers.

. . . as panel exceeds request on another

In another jurisdictional dispute, Chairman L. Mendel Rivers (D., S. C.) of the House Armed Services Committee and many of his colleagues are trying to reassert congressional control over the military. **Rivers has succeeded in pushing through Congress a procurement authorization bill that would provide more weaponry than Secretary of Defense McNamara thinks is justified.** Rivers has won committee approval for a military pay increase far greater than McNamara sought. And he has forced the defense chief to ask congressional approval for details of the merger of the Army Reserve into the National Guard.

Six studies set for DCA satellites

Six companies have received contracts from the Defense Communications Agency to conduct parallel studies, over three to four months, on an advanced defense communications satellite system.

The agency called for industry proposals from 20 companies last December. **Each of the six companies that responded—the Communications Satellite Corp., General Electric Co., Hughes Aircraft Co., Philco Corp., Radio Corp. of America and TRW Space Technology Laboratories —was awarded a contract ranging from $135,000 to $196,000.**

The advanced satellite communications system is to replace an interim satellite system the military plans to install next spring. In that program, eight satellites will be launched simultaneously atop a Titan 3C into near-synchronous orbits.

Electronics gear for Navy criticized

An article in a semiofficial Naval publication severely criticizes electronics equipment as being too complex, unreliable and difficult to maintain. The article, by Cmdr. Robert H. Smith of the Operational Test and Evaluation Force, Atlantic Fleet, appears in the June issue of Naval Institute Proceedings, a journal that disclaims official standing but that has been used for years by Navy officers to air their views.

Smith writes: "Reliability and maintainability of many of the most vital systems are unsatisfactory, a high percentage are overly complex and far more sophisticated than necessary to fulfill their mission, new systems are often demanding skills for which no trained personnel exist, and most new systems are inadequately supported."

Smith accuses top Navy officials of placing too much faith in technical advances, and industry of "the tendency to promise more than it can successfully deliver."

Design Your Product To Sell!

...with Mallory high energy batteries

Miniaturization

Battery size is often the most critical factor in establishing size of a self-powered product.

Mallory Mercury Batteries are small! In fact, Mallory makes the smallest commercially available battery . . . the Mallory RM-312. This battery is only 0.310″ by 0.135″ high, yet has 36 MAH capacity. An even smaller cell is now in advanced development.

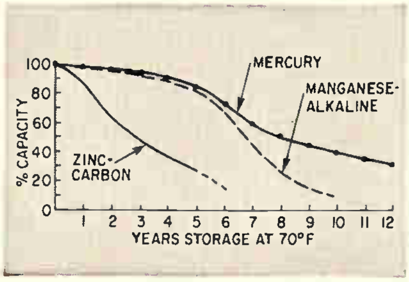
Mallory mercury cells deliver the same amount of energy as a conventional battery in ⅓ to ¼ the space . . . or 3 to 4 times the energy per unit volume of conventional batteries.

When you need a small battery for *high drain applications*, a Mallory Alkaline Manganese Battery is your best choice. It delivers 2 to 3 times the energy of conventional batteries, and has unusual staying power under heavy load conditions.

Longer shelf life for better convenience

Many battery-powered products remain idle for weeks or months, yet they're expected to spring into life on demand. Mallory batteries—both mercury and alkaline manganese—assure better product performance in intermittent service because they have far longer shelf life.

Shelf life of Mallory Mercury Batteries is exceptionally long. Even after 10 years at 68°F they have useful capacity left. Capacity loss is an amazingly low 5% per year. Ordinary zinc-carbon batteries die on the shelf in 12 to 18 months.

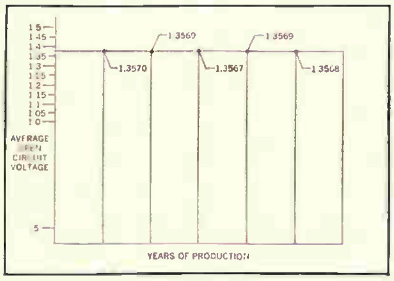


Mallory Alkaline Manganese Batteries give superior shelf life, too. They can be stored for two years or longer without serious power loss. After three years storage at 70°F, capacity of an alkaline battery is still 80% its original value.

Precision performance

Many "precision" self-powered products, such as meters, electronic watches, heart pacers, and telemetry systems require a battery with accurate, stable output voltage. Mallory Mercury Batteries offer the best stability commercially available.

Mallory Mercury Batteries are available in two standard chemical systems: with pure mercuric oxide depolarizer and with a small percentage of manganese dioxide in the depolarizer.



The pure mercuric oxide batteries . . . identified by an "R" suffix . . . have a no-load voltage of 1.350 ±0.007 volts. These are recommended where maximum voltage precision is needed. Furthermore, the no-load voltage of Mallory Mercury Batteries is extremely consistent on every production lot. The chart shows cell voltages taken from samples produced during a 5 year period.

Leading Battery Powered Products Use Mallory Batteries

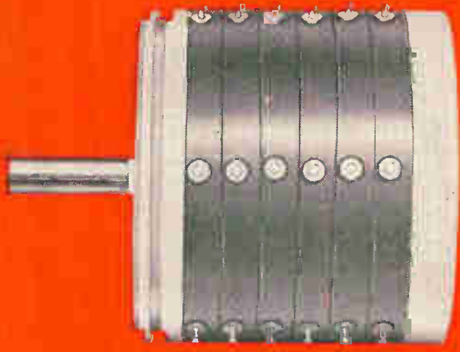
Instamatic® cameras by Eastman Kodak have built-in pop-up flash as one of their many convenience features. Mallory Alkaline Manganese Batteries supplied in Instamatic kits provide high dependability and long life, help assure correct flash synchronization and good pictures.

Motorola FM "Handie-Talkie" Radio, a two-way portable radio used by railroads, forest rangers, public safety officials and businessmen weighs only 35 ounces, measures only 8″ by 3⅛″ by 1⅝″. A tiny Mallory battery, 2¾″ x 2¾″ x 1¼″, powers this radio during 59 hours of transmitting, receiving and standby time.

Mallory batteries *cost* more but they're *worth* more because they add unique sales appeal to your product . . . better performance, smaller size, long service life between battery changes, better stability. For a consultation, write or call Mallory Battery Company, a division of P. R. Mallory & Co. Inc., Tarrytown, New York.

MALLORY

Circle 47 on reader service card→

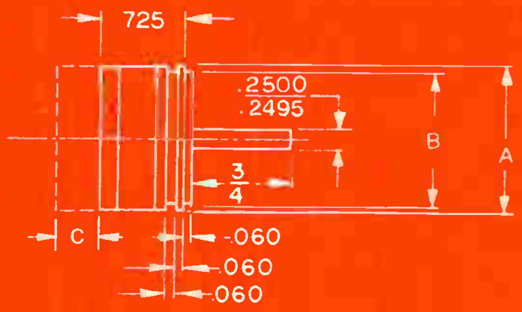


Model # 1775
Actual size

This infinite resolution rotary SLIMPOT doesn't depend on a fragile wire... performs for 10 years* —and more!

*This C.I.C. potentiometer has a life of over 75,000,000 revolutions (that's one revolution every second of every working day for over 10 years!) because the mirror-smooth surface of the continuous broad-band film resistance element permits the use of light pressure, low mass wipers, which cause only infinitesimal wear even under the most severe environmental conditions. Only C.I.C. pots use multi-fingered precious metal wipers throughout with the individual fingers tuned to different natural frequencies combined with rugged ball-bearing construction, to produce unexcelled reliability. All this in extremely compact, low torque units available with fully load compensated linear or functional outputs.

SPECIFICATIONS			
MODEL NO.	1775	2055	3055
A	1¾	2	3
B	1.5620 1.5615	1.8750 1.8745	2.8750 2.8745
C (ADDITIONAL LENGTH PER CUP)	0.200		
BEST LINEARITY	0.035%		0.02%



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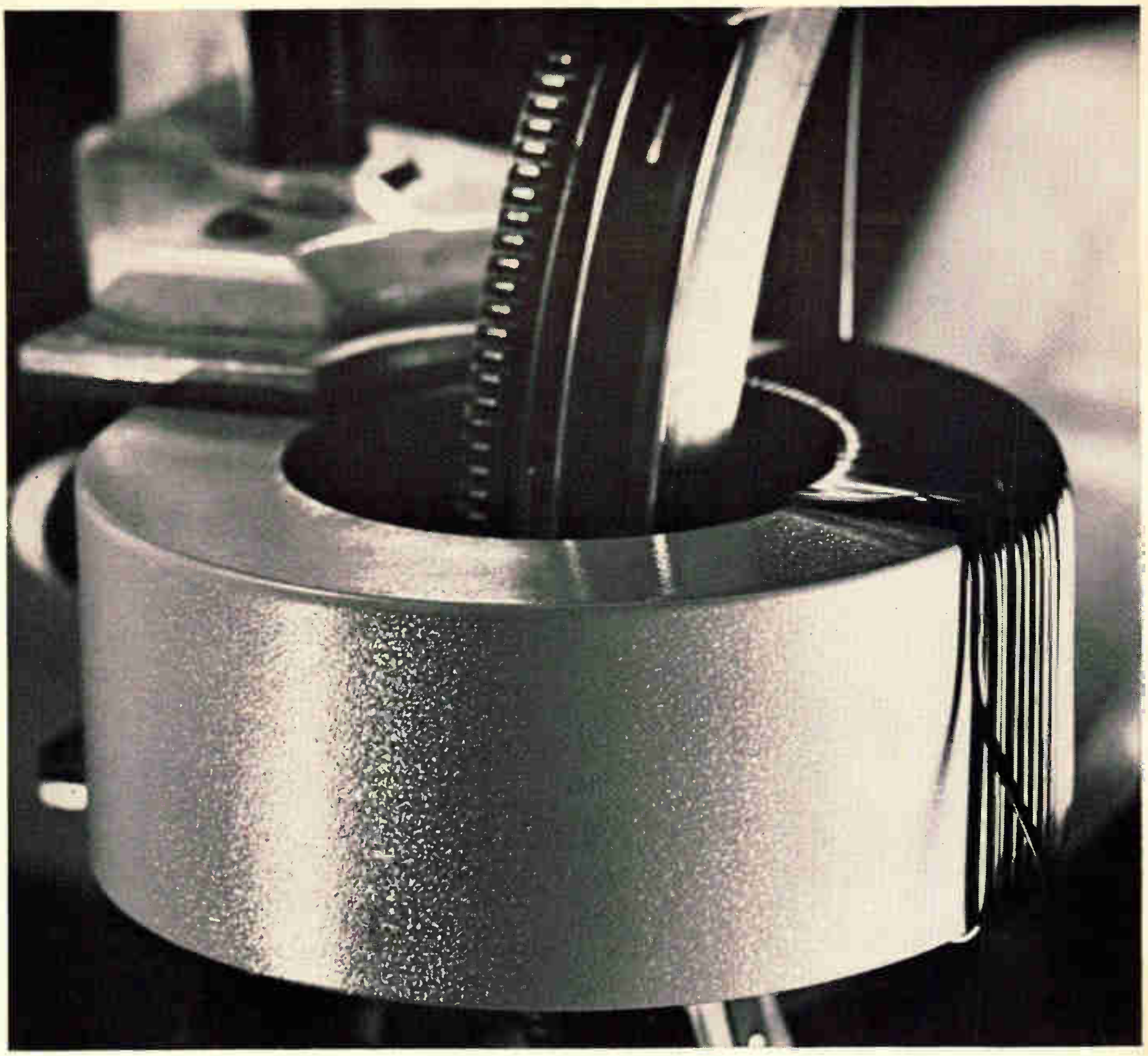


DON'T try *all* these tests on any other resistor!

11-watt unit
enlarged 2½ times

OHMITE Series 99

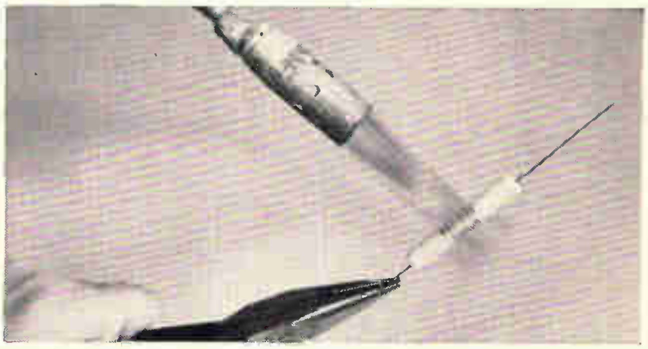
Insulated, Axial Lead Wire-Wound Resistors

"molded" in vitreous enamel

...a new development in protective coatings.

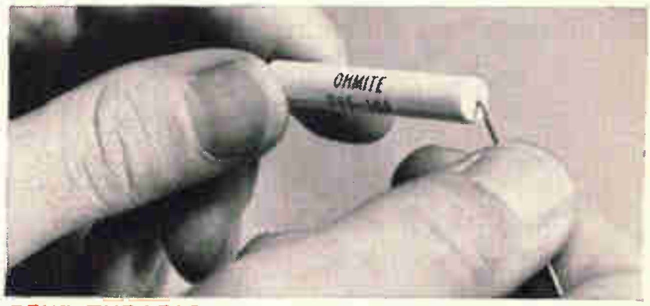
- Proved by over **24,500,000** unit-hours of load-life testing as of Oct. 1, 1964.
- Meet MIL-R-26C requirements.
- 1½, 2¼, 3¼, 5, 6½, 9, 11-watt sizes.
- Get the whole story on this important development. Write for Bulletin 103.

SOAK IT IN SOLVENT! Soak a Series 99 resistor in *any* organic solvent used in degreasing and flux removal. Then try to rub off the markings. You can't; they're *part* of the coating.

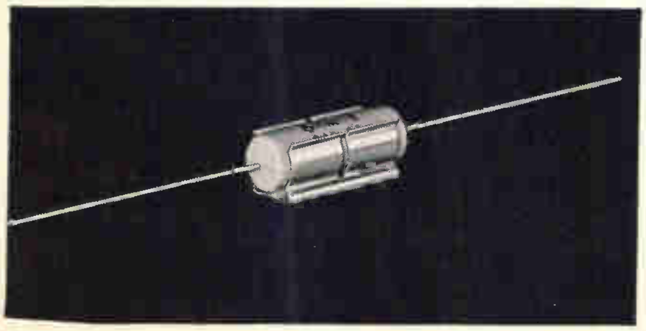


TORCH IT! Withstands temperatures of 1500°F without a sign of deformation. No other vitreous-enameled resistor will stand 1500°F without burning, softening, or dripping away. There's absolutely no effect on markings either.

ABRADE IT! Use a glass fiber eraser, for example, on the markings. Rub them hard. Nothing happens. The markings don't come off, because they are vitreous ceramic, *fired into* the molded vitreous coating.



BEND THE LEAD at the resistor body! There's no damage. Conventional (dipped) vitreous-enameled resistors have a meniscus at this point which ruptures, damaging the coating. Series 99 (molded) have no meniscus.



CLIP IT! Insert a molded Series 99 resistor into a metal clip. Don't baby it. The hard coating which provides 1000 VAC insulation won't cut, chip, or scratch. On a metal chassis, heat-sink action may increase wattage rating as much as 100%.

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PRESSURE MEASUREMENT REPORT

CEC

REPORT NUMBER 2

CEC's Universal Electromanometer combines high accuracy, stability and versatility with low cost

Due to its numerous advantages, both from the standpoints of performance and price, the CEC Universal Electromanometer System has become the standard answer wherever precise measurement of pressure is required. In aerospace, this system is commonly requested for space chambers, environment chambers, test stand facilities and wind tunnels. And in industry, it is now being used for everything from computer process control and power generation to petro-chemistry.

CEC's Universal Electromanometer is comprised basically of two parts: a transducer and a servo amplifier. Known as the Precision Pressure Balance, the transducer operates on the nondisplacement force-balance principle, affording accuracy and unique long-term calibration stability.

Components

The system components consist of a 1-164-0001 Servo Amplifier and a 4-336-0001 or 4-336-0002 Precision Pressure Balance. Additional components include the 4-332-0003 and 4-334-0001 Precision Pressure Balances for wide pressure range capability, the 37-004-0001 Multi-Channel Adapter for economical amplifier use, and three rack-mounted adapters for a choice of installation modes.

Range Capability

The standard 4-336 Precision Pressure Balance is available in ranges of ±5 psid, ±15 psid and ±60 psid; and in 5 psia, 15 psia and 60 psia ranges. Custom models are available in ranges between 1.5 psi and 150 psi. When CEC's 4-332 and 4-334 Precision Pressure Balances are included with the 4-336, the group offers a total range capability between 1.5 psi and 10,000 psi.

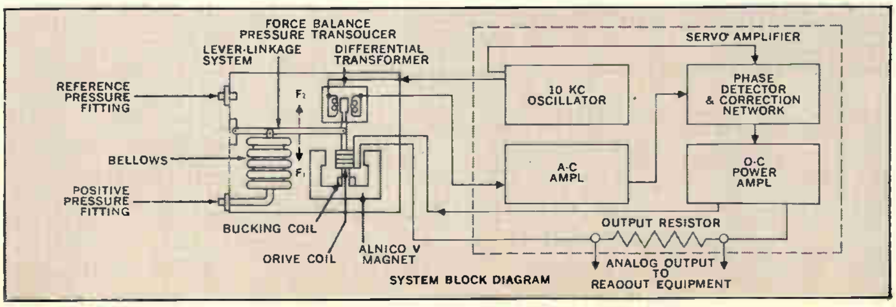
The Multi-Channel Adapter

CEC's 37-004-0001 Multi-Channel Adapter is a manual switching device that permits the use of up to six individual precision pressure balances with a single 1-164-0001 Servo Amplifier. Features include individual zero-adjusting control for each channel, individual output adjusting controls for each channel, a channel selector switch and a regulated d-c voltage supply for the electrical zero-adjust controls.

Basic functional advantages of CEC's Universal Electromanometer:

- Accuracy equals or exceeds that of precision mercury manometers; and virtually no maintenance is required.
- Sealed precision pressure balances are provided for making absolute measurements.
- Operation is foolproof and no special skill is required.
- Voltage output is unmistakable for visual, record or control.
- The amplifier is housed in a cabinet for bench use, yet is readily adaptable for rack mounting.
- Being completely versatile, it is ideal for all laboratory, field and process control applications.

For full information about CEC's Universal Electromanometer System, call or write for Bulletin CEC 1164-X23.



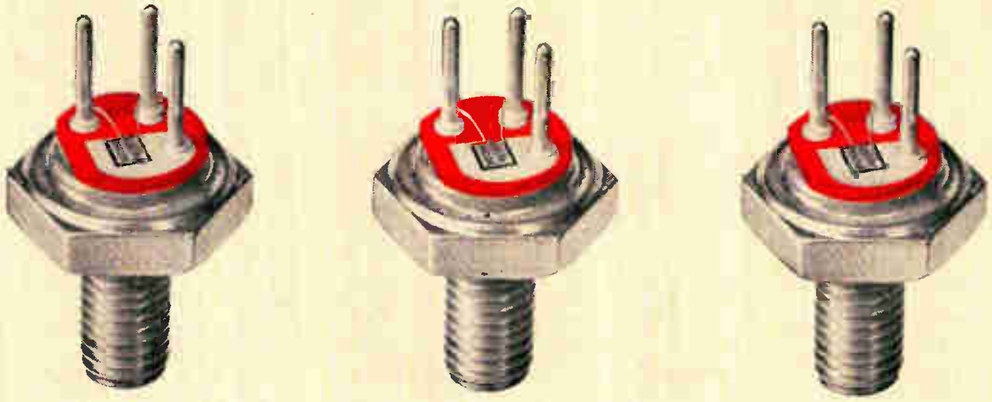
SYSTEM BLOCK DIAGRAM

CEC

Transducer Division

CONSOLIDATED ELECTRODYNAMICS

A SUBSIDIARY OF BELL & HOWELL/PASADENA, CALIF. 91109
INTERNATIONAL SUBSIDIARIES: WOKING, SURREY, ENGLAND AND FRIEDBERG (HESSEN), W. GERMANY



Honeywell now has EIA registered 5-amp planars with collector isolated from case. They'll give you greater design latitude with freedom from insulation worries. Order today from your nearest Honeywell distributor.

Honeywell

SEMICONDUCTOR PRODUCTS 1177 Blue Heron Boulevard, Riviera Beach, Florida
HONEYWELL INTERNATIONAL: sales offices in all principal cities of the world.

Type Number	Hex Dim.	DESIGN LIMITS						PERFORMANCE SPECIFICATIONS					
		T_J	θ	P_T Watts	BV_{CBO}	BV_{CEO}	BV_{EBO}	h_{FE}		V_{BE} (sat) Volts	V_{CE} (sat) Volts	I_{CBO} µA	f_T
		°C	°C/W	@100°C Case	Volts	Volts	Volts	@I_C = 1A		@I_C = 1A	@I_C = 1A	@V_{CB} = 60V	mc
		Max.	Max.	Max.	Min.	Min.	Min.	Min.	Max.	Max.	Max.	Max.	Min.
2N3744	7/16	200	3.33	30	60	40	7.0	20	60	1.2	0.25	0.1	30
2N3745	7/16	200	3.33	30	80	60	8.0	20	60	1.2	0.25	0.1	30
2N3746	7/16	200	3.33	30	100	80	8.0	20	60	1.2	0.25	0.1	30
2N3747	7/16	200	3.33	30	60	40	7.0	40	120	1.2	0.25	0.1	40
2N3748	7/16	200	3.33	30	80	60	8.0	40	120	1.2	0.25	0.1	40
2N3749	7/16	200	3.33	30	100	80	8.0	40	120	1.2	0.25	0.1	40
2N3750	7/16	200	3.33	30	60	40	7.0	100	300	1.2	0.25	0.1	50
2N3751	7/16	200	3.33	30	80	60	8.0	100	300	1.2	0.25	0.1	50
2N3752	7/16	200	3.33	30	100	80	8.0	100	300	1.2	0.25	0.1	50

Circle 51 on reader service card

World's largest selection of adjustment potentiometers

BOURNS TRIMPOT® POTENTIOMETERS

More engineers specify Bourns TRIMPOT Potentiometers because:

TRIMPOT Potentiometer line is complete:
Bourns offers you the largest selection of adjustment potentiometers...33 standard models—4 terminal types—3 mounting styles.

TRIMPOT Potentiometers are small:
Space-saving size and choice of shapes permit the installation of up to 17 units (and sometimes even more) in one square inch of panel area.

TRIMPOT Potentiometers are accurate:
Screw-driver adjustment gives as much as 9000° of rotation ...you can make and repeat the finest adjustments.

TRIMPOT Potentiometers are stable:
Adjustment shaft is self-locking...settings are virtually immune to acceleration, vibration and shock.

TRIMPOT Potentiometers are fully tested:
All units are 100% inspected before shipment and are checked by Bourns' exclusive Reliability Assurance Program to assure you of reliable performance.

TRIMPOT Potentiometers are proven:
They are backed by over 17 years of engineering know-how and have been specified and used in more military, industrial or commercial equipment than any other leadscrew potentiometer in the world!

REMEMBER—IF IT'S TRIMPOT, IT'S BOURNS

Only Bourns TRIMPOT Potentiometers Give You All Of These Outstanding Features

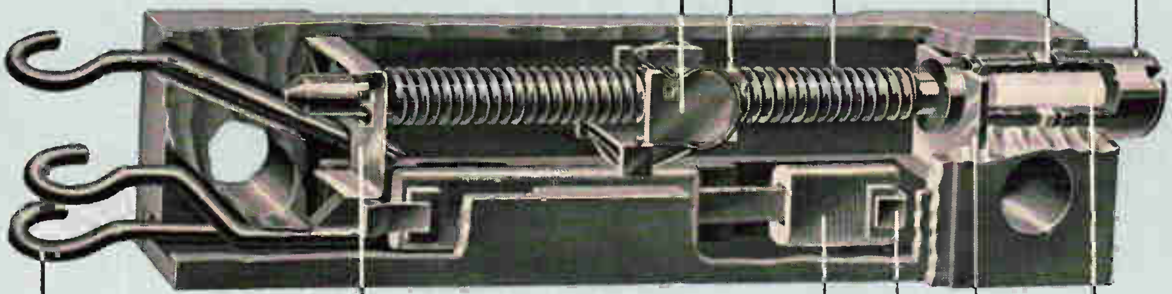
SPRING—Carriage spring provides positive no-slip performance during rotation plus a reliable idling feature at mechanical limits of travel.

LEADSCREW—Stainless steel leadscrew is corrosion-resistant.

O-RING—Silicone rubber O-ring seals potentiometer against humidity, withstands high temperature.

SHAFT HEAD—Stainless steel with machined slot for screw-driver adjustment. Meets military salt spray requirements.

WIPER—Gold-plated wiper carriage and precious-metal wiper for low noise. Carriage and wiper are welded together.



SOLDER TERMINALS—Tinned terminals are compact, yet large enough for easy soldering. Teflon-insulated leads and printed circuit pins are also available.

SILVERWELD® TERMINATION—This exclusive Bourns feature is unequalled in ruggedness. There is a metal-to-metal bond from the terminal to the resistance wire.

PICK-OFF—Precious-metal, positive-contact pick-off assures wiper continuity.

ELEMENT—Special ceramic element card for maximum reliability is precision wound with low-temperature-coefficient resistance wire.

SHAFT RETAINER—Shaft is locked in place for top performance under extreme shock, vibration and acceleration.

SHAFT INSULATOR—High-dielectric-strength, ceramic insulator isolates shaft head from internal circuits.

This cutaway of Model 224 shows the typical high quality to be found in all Bourns TRIMPOT potentiometers, although some features may vary from model to model.

...longest record of reliability

TRIMPOT® POTENTIOMETERS—UNSEALED

General-Purpose Wirewound Model 200. Max. temp. 105° C / L, S, P terminals / 0.50 watt at 70°C / 10 ohms to 100K.

General-Purpose RESISTON® Carbon Element Model 215. Max. temp. 125°C / L, S, P terminals / 0.25 watt at 50°C / 20K to 1 Meg.

High-Temperature Wirewound Model 260. Max. temp. 175°C / L, S, P terminals / 1.0 watt at 70°C / 10 ohms to 100K.

TRIMPOT POTENTIOMETERS—HUMIDITY PROOF

General-Purpose RESISTON Carbon Element Model 235. Max. temp. 135°C / L, S, P terminals / 0.25 watt at 50°C / 20K to 1 Meg.

General-Purpose Wirewound Model 236. Max. temp. 135°C / L, S, P terminals / 0.8 watt at 70°C / 10 ohms to 100K.

Micro-Miniature High-Temperature Wirewound Model 3000. Max. temp. 175°C / P terminals / 0.5 watt at 70°C / 50 ohms to 20K.

Micro-Miniature High-Temperature RESISTON Carbon Element Model 3001. Max. temp. 150°C / P terminals / 0.20 watt at 70°C / 20K to 1 Meg.

Sub-Miniature High-Temperature Wirewound Model 220. Max. temp. 175°C / L, W terminals / 1.0 watt at 70°C / 10 ohms to 30K / Mil-Spec style RT10 and meets MIL-R-27208A.

High-Temperature Wirewound Model 224. Max. temp. 175°C / L, S, P terminals / 1.0 watt at 70°C / 10 ohms to 100K / Mil-Spec style RT12 and meets MIL-R-27208A.

Ultra-Reliable High-Temperature Wirewound Model 224-500. Max. temp. 150°C / L, P terminals / 0.5 watt at 70°C / 100 ohms to 20K. Performance and reliability statistically verified to customer.

High-Temperature, High-Resistance RESISTON Carbon Element Model 3051. Max. temp. 150°C / L, S, P terminals / 0.25 watt at 50°C / 20K to 1 Meg / Mil-Spec style RJ11 and meets MIL-22097B.

High-Temperature High-Resistance PALIRIUM® Film Element Model 3052. Max. temp. 175°C / L, P terminals / 1.0 watt at 70°C / 10K to 1 Meg.

High-Temperature, Low-Resistance PALIRIUM Element Model 3053. Max. temp. 175°C / L, P terminals / 0.5 watt at 70°C / 2 ohms to 100 ohms.

High-Temperature Wirewound Model 3010. Max. temp. 175°C / L, P terminals / 1.0 watt at 70°C / 10 ohms to 100K / Mil-Spec style RT11 and meets MIL-R-27208A.

High-Temperature RESISTON Carbon Element Model 3011. Max. temp. 150°C / L, P terminals / 0.25 watt at 50°C / 20K to 1 Meg / Mil-Spec style RJ11 and meets MIL-R-22097B.

High-Temperature High-Resistance PALIRIUM Element Model 3012. Max. temp. 175°C / L, P terminals / 1.0 watt at 70°C / 10K to 1 Meg.

3/8"-Square Wirewound Model 3280. Max. temp. 175°C / L, P, W terminals / 1.0 watt at 70°C / 10 ohms to 50K.

3/8"-Square RESISTON Carbon Element Model 3281. Max. temp. 150°C / L, P, W terminals / 0.5 watt at 50°C / 20K to 1 Meg.

1/2"-Square, High-Temperature Wirewound Model 3250. Max. temp. 175°C / L, P, W terminals / 1.0 watt at 70°C / 10 ohms to 50K / Mil-Spec style RT22 and meets MIL-27208A.

1/2"-Square High-Temperature RESISTON Carbon Element Model 3251. Max. temp. 150°C / L, P, W terminals / 0.50 watt at 50°C / 20K to 1 Meg / Mil-Spec style RJ22 and meets MIL-R-22097B.

BOURNS® SINGLE-TURN POTENTIOMETERS

5/16"-Diameter Micro-Miniature High-Temperature Humidity-Proof Wirewound Model 3300. Max. temp. 175°C / P, S terminals / 0.5 watt at 70°C / 50 ohms to 20K.

5/16"-Diameter Micro-Miniature High-Temperature Humidity-Proof RESISTON Carbon Element Model 3301. Max. temp. 150°C / P, S terminals / 0.25 watt at 70°C / 10K to 1 Meg.

Sub-Miniature Wirewound Model 3367. Max. temp. 105°C / P, S terminals / 0.5 watt at 70°C / 10 ohms to 20K / meets steady-state humidity.

Sub-Miniature RESISTON Carbon Element Model 3368. Max. temp. 105°C / P, S terminals / 0.25 watt at 50°C / 20K to 1 Meg / meets steady-state humidity.

LOW-COST COMMERCIAL POTENTIOMETERS

Wirewound TRIMIT® Potentiometers Models 271, 273, 275. Max. temp. 85°C / L, S, P terminals / 0.5 watt at 25°C / 50 ohms to 20K.

RESISTALOY® Carbon Element TRIMIT Models 272, 274, 276. Max. temp. 85°C / L, S, P terminals / 0.2 watt at 25°C / 20K to 1 Meg.

Wirewound E-Z-TRIM® Potentiometer Model 3067. Max. temp. 85°C / S, P terminals / 0.5 watt at 25°C / 100 ohms to 20K / Priced under $1 in production quantities.

Carbon Element E-Z-TRIM Potentiometer Model 3068. Max. temp. 85°C / S, P terminals / 0.2 watt at 25°C / 20K to 1 Meg.

SPECIAL-PURPOSE POTENTIOMETERS

High-Power (2 watts) High-Temperature Wirewound Model 207. Max. temp. 175°C / L terminals / 2 watts at 50°C / 100 ohms to 100K. As Rheostat Model 208, available 100K to 200K.

High-Power (5 watts) Humidity-Proof Wirewound Model 3020. Max. temp. 200°C / L terminals / 5.0 watts at 25°C / 100 ohms to 50K.

Dual-Element Wirewound TWINPOT® Potentiometer Model 209. Max. temp. 135°C / L terminals / 0.50 watt (each element) at 70°C / 10 ohms to 50K.

15 watts, High-Temperature Wirewound Model 3030. Max. temp. 265°C / L terminals / 15 watts at 25°C / 10 ohms to 10K.

Radiation-Resistant, High-Temperature Wirewound Model 3040. Max. temp. 350°C / W terminals / 5.0 watts at 70°C / 500 ohms to 20K.

PANEL-MOUNTED POTENTIOMETERS

Most models are available with panel mounting. Unique design permits quick factory assembly to "on-the-shelf" units. In addition, mounting screws, brackets and clip brackets are available to meet almost any mounting requirement.

KEY TO TERMINAL TYPES

L=Insulated stranded leads

S=Solder lugs (includes panel-mounting bushing on Models 3367S, 3368S, 3300S and 3301S only)

P=Printed-circuit pins

W=Uninsulated wires (edge-mounting 3250, 3251, 3280 and 3281).

Write **TODAY** for detailed specifications on any model in the large BOURNS® Potentiometer and TRIMPOT® Potentiometer line AND a list of factory representatives.

**Remember—
Don't MIL-SPECulate...
SPECify Bourns.**

TRIMPOT is a registered trademark of Bourns, Inc.

BOURNS

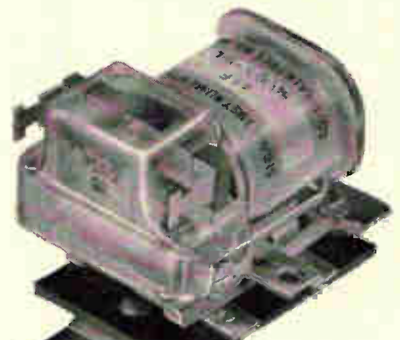
BOURNS, INC., TRIMPOT DIVISION
1200 COLUMBIA AVE., RIVERSIDE, CALIF.
PHONE 684-1700 · TWX: 714-682 9582
CABLE: BOURNSINC.

MANUFACTURER: TRIMPOT® & PRECISION POTENTIOMETERS, RELAYS; TRANSDUCERS FOR PRESSURE, POSITION, ACCELERATION. PLANTS: RIVERSIDE, CALIFORNIA; AMES, IOWA; TORONTO, CANADA

Circle 53 on reader service card

Sigma relay of the month

Built to last 30 years. Rugged industrial relay with pivotless hinge construction.



The Sigma Series 41 SPDT relay assures extra long service life in general purpose applications ranging from airport lighting systems to smoke detection controls. Its mechanical life is rated at 1 billion operations minimum. That's equivalent to 1 operation per second, 24 hours a day for over 30 years.

One reason why it can last so long is its pivotless hinge construction and extra long beryllium copper spring arm. Another is "balanced design" which includes the following characteristics and benefits: 1. High coil overload capacity: operates efficiently at control voltages 4 to 6 times rated coil input. 2. Extended contact life: heavy-duty design of stationary contacts minimizes effects of contact erosion. 3. Broad load carrying capacity: from dry circuit to as high as 10 amps. 4. Clean switching: small mass of armature contact minimizes contact bounce. 5. Versatility: wide variety of enclosures, adjustments, contact materials, coil resistances and operating characteristics to meet all kinds of industrial conditions and applications. 6. UL listed.

Test all of these "balanced design" features—free—and prove for yourself that the Sigma Series 41 will outperform any other comparable relay in your industrial applications. Just send for the Sigma Series 41 bulletin and a free relay redemption certificate.

SIGMA DIVISION SIGMA INSTRUMENTS INC

Assured Reliability With Advanced Design/Braintree 85, Mass.

"Least likely to succeed" has made it big!

With Mr. Samuel B. Mosher, who pioneered Signal Oil & Gas Co. and many other ventures, matching what we thought was our enormous fortune, we took off.

And what happened? We have become the world's largest all-cargo airline. We have flown more than 227-million miles. We have brought costs of shipping by air down 70% from where they were twenty years ago. We have helped create markets where none existed before.

We feel it is an appropriate time to say, "Thank you!" And whom do we thank?

First, we thank you, the shippers. Without your patience and support we could have gone no place. Together with you we have been able to help build the world's finest system for low-cost air transport of goods.

We thank the stockholders and investors who have had the faith to support our efforts.

And we thank America for being what it is; for being the fertile land where things can grow with the right direction and the right effort; for the freedom it gives you to make a place in the sun for yourself if you've got the guts to go after it and stay with it.

It has been a long twenty years and also a short time. We look forward to the next twenty with confidence. As the leading all-cargo carrier we have a responsibility to the business community of America. With your continued support we shall always honor that responsibility.

Sincerely,

Robert Prescott, President
Flying Tiger Line Inc.

CIRCLE 57 ON READER SERVICE CARD

little  *switch*

BIG SAVINGS

Half the cost of conventional multi-position switches and loaded with multiple performance design advantages. Spectrol's miniature switches give you performance characteristics for printed and micro-circuit applications never before available in so small a package at such low prices. Reliable, trouble free operation is assured by the unique construction features of the type 88 rotary indexing switches.

DIRECT MOUNTING — Reduces wiring costs — mounts directly on printed circuit boards.

TROUBLE-FREE OPERATION — Contacts are kept free of oxides and other harmful film deposits by the self scrubbing design that polishes during every duty cycle.

FULL POTTING PERMITTED — Dust-free, moisture-free operation insured by silicone rubber scaling and packing gland techniques.

MILITARIZED — Designed to stand up under high shock, vibration, temperature extremes, and other severe environments per MIL-STD-202B.

LOW ARCING — LOW NOISE — Higher contact force and elimination of tracking made possible by the cam actuated "lift-off," "drop-on" wiper action.

THREE CONFIGURATIONS — Choice of knob, screw driver adjust or bushing panel mount.

88-3-8 SLOTTED HEAD — 88-3-10 KNOB — 88-5-6 BUSHING

ACTUAL SIZE

BRIEF SPECIFICATIONS **MODEL 88**

Switch type..............Single pole, 10 position, non-shorting
Switch action............Positive detent action, 36° indexing
Current rating..........250 MA at 28 VDC
Case dimensions (inches)............... $^{3}/_{16}$ H max x $^{1}/_{2}$ D (88-3-8)
Price 1 to 9 pieces....$3.75

Call your nearest Spectrol distributor for immediate off-the-shelf delivery at factory prices, or write for complete specifications. Spectrol also manufactures a complete line of trimming potentiometers and turns-counting dials.

SPECTROL ELECTRONICS CORPORATION

1704 South Del Mar Avenue
San Gabriel, California

Adams Court
Plainview, L.I. New York

Circle 61 on reader service card→


TEFLON® FEP
A unique new
fluorocarbon film
that may help you solve
your toughest
design problems
DU PONT

New TEFLON* FEP film offers most critical environments...

New TEFLON FEP fluorocarbon film has a combination of properties never available before in any plastic film. It has the anti-stick, chemically inert characteristics of a pure fluorocarbon material...*plus* the variety of forms and ease of use of a true thermoplastic film. This combination can open exciting new design possibilities to you.

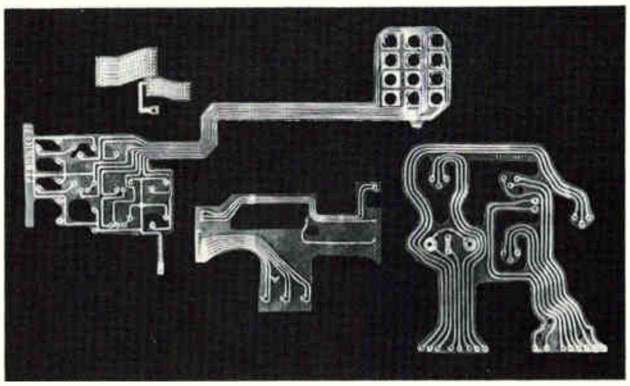
TEFLON FEP film offers extremely high reliability under difficult and demanding environmental conditions. Its continuous service temperature ranges from −425° to +400°F. (−255° to +200°C.); it is nonflammable and has superior electrical properties. It is now being produced in rolls, sheets and tubing in commercial quantities under rigid quality control standards.

If you would like to investigate a potential application in which new TEFLON FEP film can solve a tough design problem, mail the coupon for complete data and assistance.

Here's how others are using TEFLON FEP film!

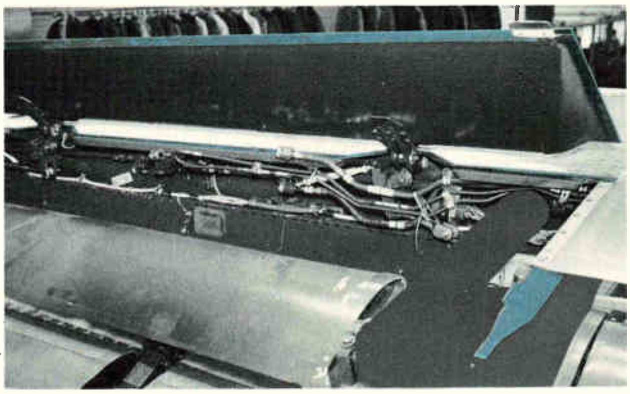
Flexible Connector Ducting

Made by: Arrowhead Products Division, Los Alamitos, Calif.
Construction: Sealed and formed missile fuel-system ducting.
Advantages of TEFLON FEP film: Chemical resistance, liquid oxygen compatibility; also avoids costly and elaborate forming and machining.



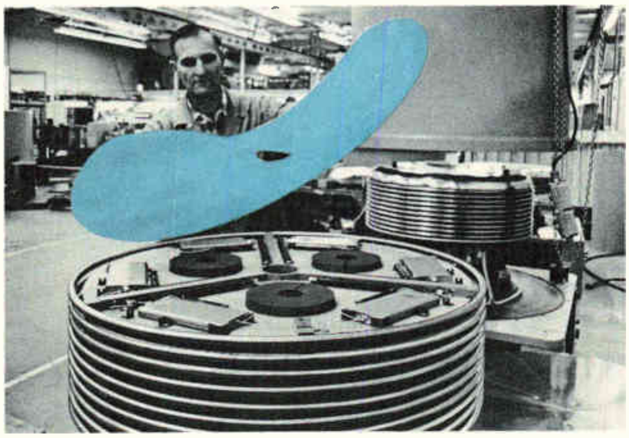
Flexible Circuits

Made by: Garlock, Inc., Cherry Hill, New Jersey.
Construction: Copper laminated between two layers of TEFLON FEP film.
Advantages of TEFLON FEP film: Greater design freedom, reduction of circuit weight and size, superior electrical characteristics and maximum reliability under all environmental conditions.



Dry Surface Lubricant—F-111 Aircraft

Made by: General Dynamics Corporation, Fort Worth, Texas.
Construction: TEFLON FEP film laminated to surfaces in F-111 wing.
Advantages of TEFLON FEP film: Low coefficient of friction, unaffected by fuels and oils, withstands wide temperature ranges and a consistently reliable adherable surface.



High Voltage Accelerator Insulator

Made by: High Voltage Engineering Corp., Burlington, Mass.
Construction: Circular sheet of 60 mil TEFLON FEP film.
Advantages of TEFLON FEP film: Superior electrical properties, high temperature stability and long life usage make TEFLON FEP film the only one that can be used.

*Du Pont's registered trademark for its FEP fluorocarbon film.

maximum reliability in the plus wide design flexibility

"TEFLON" FEP film offers these outstanding properties

PHYSICAL

PROPERTY	TYPICAL VALUE
Ultimate Tensile Strength (MD)	3000 psi.
Yield Point (MD)	1700 psi. at 3%
Stress at 5% Elongation (MD)	1900 psi.
Ultimate Elongation (MD)	300%
Tensile Modulus (MD)	70,000 psi.
Impact Strength	2 kg.-cm./mil
Folding Endurance (MIT)	4000 cycles
Tear Strength—propagating (Elmendorf)	125 gms./mil
Tear Strength—initial (Graves)	270 gms./mil
Tear Strength—initial (Graves)	600 lbs./in.
Bursting Strength (Mullen) (1 mil)	11 psi.
Density	2.15
Coefficient of Friction (Kinetic) (Film-to-Film)	.57
Refractive Index (Abbé)	1.341-1.347
Area Factor	12,900 sq. in./lb./mil

THERMAL

PROPERTY	TYPICAL VALUE
Melting Point (°F.)	500°-535°F.
(°C.)	260°-280°C.
Service Temperature—continuous	
(°F.)	−425° to +400°F.
(°C.)	−255° to +200°C.
Intermittent	
(°F.)	−425° to +525°F.
(°C.)	−255° to +275°C.
Coefficient of Linear Expansion	4.61 x 10^{-5} in./in./°F. at −100°F.
	5.85 x 10^{-5} in./in./°F. at +160°F.
	9.0 x 10^{-5} in./in./°F. at +212°F.
Coefficient of Thermal Conductivity	$1.35 \frac{\text{(BTU) (in.)}}{\text{(ft.}^2\text{) (hr.) (°F.)}}$
	$4.65 \times 10^{-4} \frac{\text{(cal.) (cm.)}}{\text{(cm.}^2\text{) (sec.) (°C.)}}$
Flammability	Non-flammable
Heat Sealability	Yes
Specific Heat	0.28 BTU/lb./°F.
Shrinkage (1 mil)	MD=0.7% stretch
	TD=2.2% shrinkage

CHEMICAL

PROPERTY	TYPICAL VALUE
Chemical Resistance: Resistant to practically all chemicals except fluorine at temperatures above 200°C., molten alkali metals and certain complex halogenated compounds.	
Moisture Absorption	Less than 0.01%
Weatherability	Inert Outdoors
Permeability	
Gas	cc./(100 sq. in.) (24 hrs.) (atm./mil)
Carbon Dioxide	1,670
Hydrogen	2,200
Nitrogen	320
Oxygen	750
Vapors	gms./(100 sq. in.) (24 hrs./mil)††
Acetic Acid	0.41
Acetone	0.95
Benzene	0.64
Carbon Tetrachloride	0.31
Ethyl Alcohol	0.07
Hexane	0.56
Water	0.40

††Vapor permeabilities are determined at the partial pressure of the vapor at the temperature of the test.

ELECTRICAL

PROPERTY	TYPICAL VALUE
Dielectric Strength (1 mil)	6500 volts mil at 25°C., 60 CPS
Dielectric Strength (20 mil)	1800 volts mil at 25°C., 60 CPS
Dielectric Constant	2.0 at 25°C., 100 CPS to 100 MC
Dielectric Constant	2.02-1.93 at 1KC, −40° to 225°C.
Dissipation Factor	.0002-.0007 at 25°C., 100 CPS to 100 MC
Dissipation Factor	.0002 at 1KC, −40° to 225° C.
Dissipation Factor	.0005 at 100 MC, −40° to 240° C.
Volume Resistivity	$>10^{17}$ ohm-cm. } 40° to 240°C.
Surface Resistivity	$>10^{16}$ ohm.sq. } 40° to 240°C.
**Surface Arc Resistance	>165 sec.

**Samples melted in arc—did not track.

Mail this coupon to get complete technical data and assistance. Tell us what your specific product or application interests are so we can answer your inquiry most effectively.

Nature of interest or problem (please be specific):

____

____

____

____

☐ Send technical data only.
☐ Have a Du Pont representative contact me.

Name ______________________________

Position ______________________________

Company ______________________________

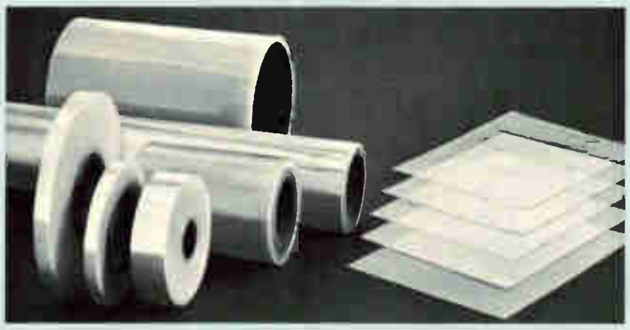
Address ______________________________

City ______________ State ______________ Zip No. ______________

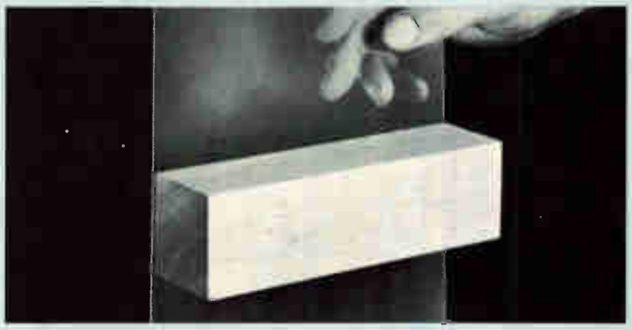
Business Phone ______________________________

TEAR OFF CARD AND MAIL

Available in a wide variety of forms

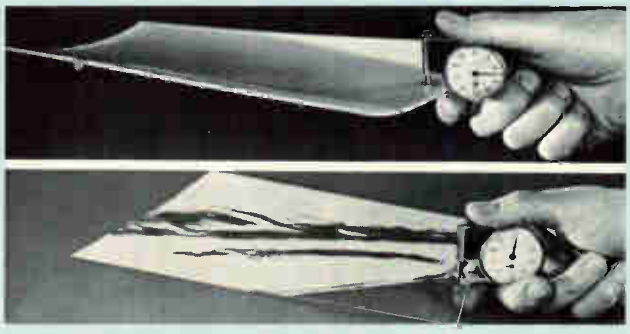


PLAIN FILMS. Standard types come in ½, 1, 2, 5, 10 and 20 mil thicknesses. Roll widths from ½" to 48" in 1/16" increments. Also available in sheets. Special films for uses requiring high flex under environmental extremes.



CEMENTABLE FILMS. Standard types with one side modified to accept conventional adhesives. Special film with both sides cementable is available in 1, 2, 5 and 10 mil thicknesses. All are transparent.

HEAT SHRINKABLE TUBING. Many sizes from 1" up to 8" I.D. are available, in lengths up to 10 feet. Heat shrinkable at 220°F.



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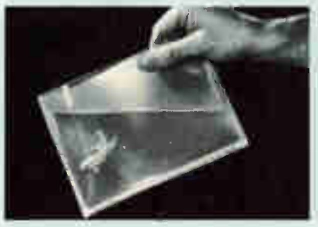

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BETTER THINGS FOR BETTER LIVING
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Technical Articles

Automating production of hybrid microcircuits: page 66

A new technique blends face bonding, a reliable method of attaching active devices to passive networks, with batch processing of passive networks to make more reliable hybrid integrated circuits automatically. Semiconductor chips, mounted on pads, are welded facedown to thin-film conductors. For the cover, art director Saul Sussman magnified a flip chip made by the new process, superimposed it on an active background and produced this piece of op art.

Low-light tv that is better than the human eye: page 78

New television cameras being developed for the military take pictures by starlight. All three services are experimenting with tv cameras and image intensifiers to detect objects at any time between twilight and dawn, when the light level may vary from 10^{-1} to 10^{-4} footcandles. Both the Radio Corp. of America and the General Electric Co. are developing rugged vidicons and highly sensitive orthicons.

Stored charge on diode defines switching speed: page 84

As diode switching speeds get faster, the engineer has a more difficult time measuring and specifying them. In high-speed circuits, the stored charge offers a better standard than the present method which is based on the reverse recovery time of the diode.

Examining biotelemetry design: page 89

In the second of two articles on the new discipline of bioengineering, the authors describe designs of some special equipment, explaining why unusual approaches were needed. The equipment developed includes an implant transmitter that weighs only 0.4 grams, a six-channel multiplex telemetry system, and an r-f powered implant device.

Coming July 12

- **Microelectronic transducers**
- **Stress-sensitive integrated circuits**
- **Curves for a single-band circuit**
- **Wireless flatpacks for integrated circuits**

Crossbred technology automates production of hybrid microcircuits

Microcircuit fabrication system uses pad-terminated semiconductor chips, welded facedown to thin-film conductors, and screen-printed ceramic capacitors

By John G. Curtis
Electronic Products Division, Corning Glass Works, Raleigh, N.C.

Face bonding, an advanced method of attaching active devices to thin-film passive networks, is inherently more reliable and less expensive than the usual methods of assembling hybrid microcircuits.

Conventionally, discrete devices are attached to the networks by welding or soldering their leads one at a time to the thin films. If the components are semiconductor chips, the chips are soldered to the substrates and leads bonded individually to thin-film terminals on both the chip and the network. These procedures are long on manual labor and short on improving circuit performance and reliability.

In face bonding, the semiconductor chips are provided with small mounting pads, turned upside-down and bonded directly to the ends of the thin-film conductors on the passive substrate, as shown on page 70.

This improves reliability because the number of bonds are cut at least in half, compared to bonded lead wires. The facedown mounting protects the devices and the absence of lead wires provides a solid structure that can be encapsulated with glass or plastic.

Moreover, face bonding is suited to automation, with further advantages in quality control and cost. The chip can be mechanically positioned on the substrate and all bonds welded simultaneously. Face bonding can be used to attach complete monolithic silicon circuits to the passive network as well as individual devices.

A new microcircuit fabrication system, one that crossbreeds face bonding with several batch-fabrication methods of producing passive networks, has been put into operation at the Electronic Products division of Corning Glass Works.

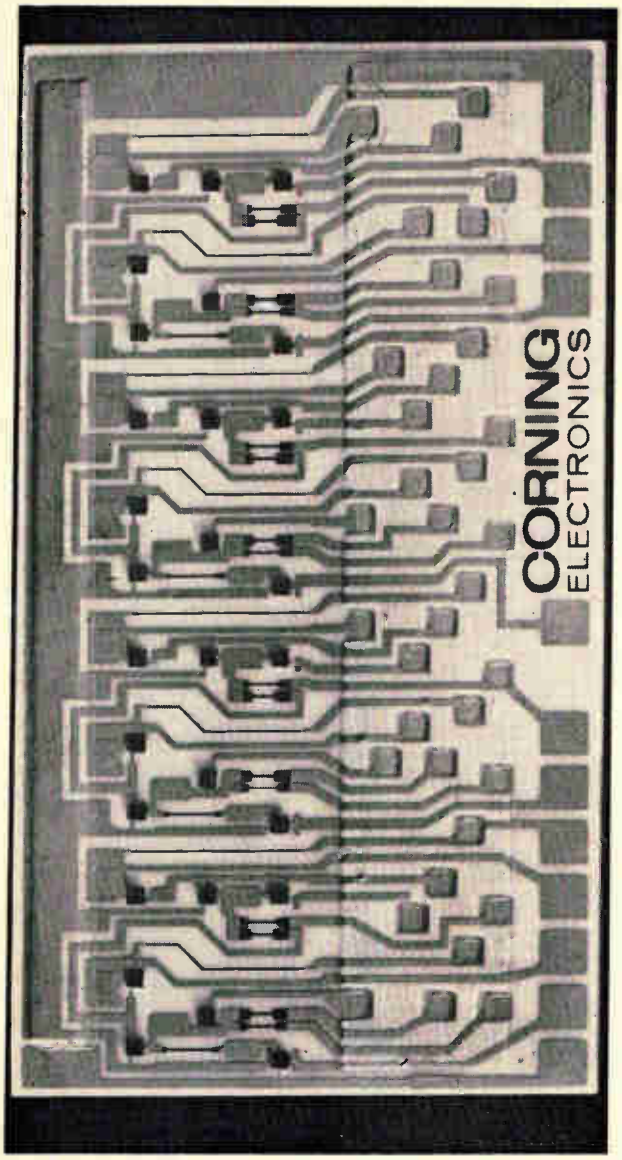
Face bonding permits many types of active devices, in semiconductor chip form, to be processed, selected and attached to the networks by automatic equipment. The mating of several batch fabrication methods enables the passive networks to be made without discrete components in a sequence of mechanized operations.

This crossbred technology, one which really merits the term hybrid, solves problems of circuit speed and power, as well as interconnection reliability, process automation and yield. Developed to supply competitively priced, high-performance circuits to system manufacturers, it makes practical the production of highly complex circuits with the same facilities used to make simple ones.

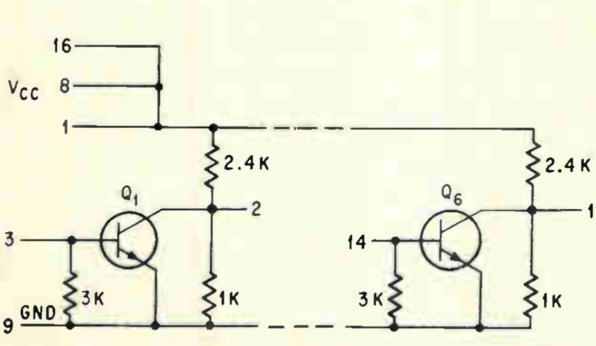
The full range of process capability is illustrated on page 67 in a functional network that contains 64 components and 102 conductor crossovers. Other examples are given on page 70 and on the cover. The cover drawing shows a chip circuit called the Sixpac, which contains six diode-transistor-logic inverters. The Sixpac has six face-bonded tran-

The author

John G. Curtis is best known for his reports on the use of current-noise measurements for failure analysis of resistors. Now supervisor of microcircuit reliability in Raleigh, he joined Corning in 1959 as a capacitor engineer at the company's plant in Bradford, Pa., his home town. Previously, he was a field engineer with the Sperry Rand Corp. He served four years in Japan as a Navy material planning officer.



Bonded wire leads, generally used to connect active devices and capacitors to resistor-conductor networks, are missing from this hybrid microcircuit. The circuit has 28 face-bonded semiconductor devices (the black squares), 28 resistors (black lines), eight film capacitors (squared patterns at the left) and 102 conductor crossovers (gold stripes, invisible under a glaze, running vertically at the right). The conductors atop the glaze reach the stripes through windows in the glaze.



Schematic of Sixpac, showing first and last stages and pin numbers. An artist's rendering of this chip circuit made up of six logic inverters is on the cover.

sistors and is designed for use with inexpensive discrete diodes for the actual gating. It may be used with any combination of input gates. Its size and complexity are about half those of conventional hybrid circuits.

Marriage of methods

The passive networks are produced by a sequence of screen printing, deposition and plating methods that are all done at atmospheric pressure. This means that processing and adjustment of the networks can be automated readily, unlike vacuum techniques which are difficult to mechanize and therefore expensive. Some other advantages:

- Resistors are made by the pyrolytic deposition of tin oxide. Such resistors in discrete form are known for their stability and adaptability to worst-case circuit design.
- The tin oxide is a base for plated copper conductors. The oxide is precision etched to define resistor and conductor geometries, so additional registration or etching of the conductor pattern is avoided.
- Film ceramic capacitors are built on the substrate by screen printing. Each is hermetically sealed by a layer of glass. The capacitors are similar in performance to the best discrete ceramic capacitors.
- Most thin-film techniques require additional processing steps to insulate conductors that cross one another. Corning makes crossover runs of screen-printed gold and glass at the same time the capacitors are made, or can use the glazed surface of the capacitors for crossovers.
- Since conductor lengths can be minimized by the use of crossovers and the elimination of wire leads, signal transit times are less, increasing operating speed of the circuits.

Face bonding the chips

Vacuum deposition does have a role in the production process. As is usual in planar processing, thin-film aluminum electrodes are deposited on the devices before the silicon wafer is diced. Then a proprietary process, applied at atmospheric pressure, builds up the metallizing to form the thick pads, or lands, seen in the sketch on page 70.

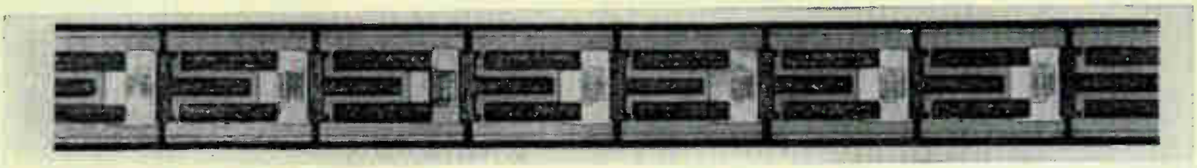
Three high-speed, tape-controlled systems handle the active devices. One forms the lands on the passivated silicon wafers, the second orients and electrically tests the chips by means of the lands, and the third positions and bonds the chips.

While the lands may be located anywhere on the face of standard 30-mil-square chips, in fast devices, capacitance between the electrodes and the silicon—chiefly the collector bulk—must be minimized by making the thin-film electrodes short and narrow. If collector saturation voltage must be low, resistance between the collector connection and the base-collector junction is lowered, usually by making the collector window large.

(Continued on p. 70)

Bumps and balls, pillars and beams: a survey of face-bonding methods

By George Sideris
Manufacturing Editor



Beam leads provide a large handle for tiny transistor chips (the smallest visible squares). Such strips could be fed to automatic bonding machines.

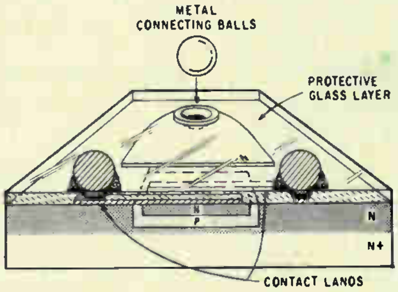
The **face-bonding** bandwagon is picking up speed. Only a few companies are now producing face-bonded hybrid microcircuits but many others are running to catch up and climb aboard.

Most of the advantages cited in John Curtis' article on page 66 will interest systems manufacturers, manufacturers of semiconductor devices and integrated circuits, and manufacturers of commercial hybrid circuits. However, systems manufacturers are especially interested in techniques like the flip-chip and pillar methods described below that don't require specialized processing of the chips to form the bonding pads and could use anybody's chips.

Semiconductor manufacturers see face bonding as a likely way to cut packaging costs. A chip that can be bonded to a hybrid-circuit substrate can just as easily be bonded to a package base, and since there are no leads, it is more feasible to package the devices with solid glass or plastic, instead of a can.

Most companies developing face-bonding methods are wary of disclosing details of face-bonding materials and their processing, since this is the heart of any technique. However, one can clearly discern several growing families of face-bonding methods.

Flip-chips. One of the earliest face-bonding techniques is the one that the General Electric Co. dubbed flip chip a couple of years ago. This is a process for bonding arrays of many integrated circuits to thin-film interconnection patterns on a substrate [Electronics, Oct. 18, 1963, p. 82]. The circuits' thin-film terminals are bonded directly to the substrate's thin films.



Soldered balls are one way of providing chips with contacts.

The method is not in wide use because the bonds cannot be seen and it is difficult to assure that they have been made, or that individual bonds are strong. As a consequence, several companies are using a reverse of the procedure—putting conductors atop the chips so that individual bonds can be inspected. Topping the chips with conductors can be accomplished by bonding etched-foil patterns to the terminals on the chip, or by fastening the chip face-up to the substrate and depositing the interconnection film simultaneously on both the chip and the substrate.

Balls. Most devotees of face bonding seem to think, however, that it is better to raise the chip slightly above the substrate with a thick bonding pad of some sort. This gives more leeway in aligning the planes of the chip and the substrate. Three pads on the chip are sufficient to define the plane. Mating is easier if the material is soft, like solder. Raising the chip makes it possible to inspect the bonds visually.

The most famous of the three-point bonding methods is the one using mounting balls that the International Business Machines Corp. devised for the circuits of its System/360 computers [Electronics, April 20, 1964, p. 103] shown at left.

This method, like Corning's, starts with silicon wafers. IBM coats its wafers with glass, etches holes in the glass to expose the device terminals, then coats the holes with solder. Balls are fused into the holes by heating the solder. Subsequently, the balls on the diced chips are bonded to the circuit substrates by reflowing a solder coating on the substrates' screen-printed conductors. This process, too, has been highly automated.

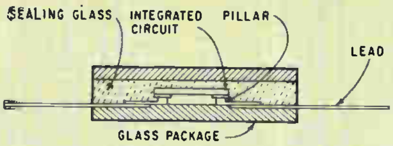
Bumps. There is a family resemblance between the Corning pads, the IBM balls and the bump contacts that are used by the Hughes Aircraft Corp. and the Burroughs Corp. [Electronics, March 8, 1965, p. 75].

Hughes makes several types of devices with solderable bump contacts and has found that the bumps can be ultrasonically welded to thin films. The Burroughs devices are face bonded to solder-coated, screen-printed conductors. The drawing at right shows the structure of one Burroughs chip, a pair of npn and pnp transistors connected in a feedback loop. For orientation of four-terminal devices, one of the terminals is made larger than the other, as shown by the photo on the facing page.

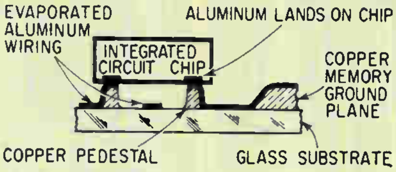
Pillars. If the bumps are transferred to the substrate, a composite of the flip-chip and bump methods results. Such a method is under development at the Signetics Corp., a Corning subsidiary. The bumps, called pillars at Signetics, are made by thickening the ends of thin-film conductors on the substrate. Signetics' prime interest is glass encapsulation of packaged integrated circuits, as illustrated, but hybrid circuit applications are also contemplated.

The Univac Division of the Sperry Rand Corp. is developing a way of attaching integrated circuits to the glass substrates of thin-film memory planes. Plans are to bond up to 200 circuit chips, to form complete memory systems. The bumps, which Univac calls pedestals, can be etched from the same copper layer that forms the memory ground plane, as shown at right. Ultrasonic welding bonds the aluminum thin film on the chip to a coating of aluminum evaporated on the pedestals.

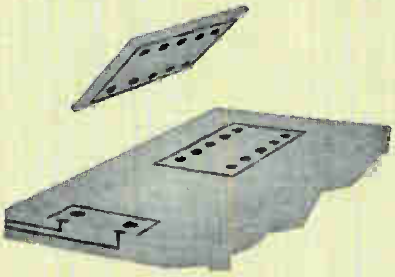
Another variation on this theme is the multilayer ceramic substrate concept being pursued by the Autonetics division of North American Aviation, Inc. As the drawing indicates, the integrated-circuit chip will be hermetically sealed at the same time it is bonded by means of the bond stripe that encloses the land patterns. This approach is a chip-circuit equivalent of the multilayer printed circuit board method of interconnecting large numbers of packaged circuits.



Pillar-bonding method allows integrated circuits to be hermetically sealed in solid glass package.



Bonding pedestals can be fabricated at the same time a thin-film memory is made, and memory circuits attached.



Multilayer ceramic circuits might solve bonding, sealing and interconnection-crossover problems.

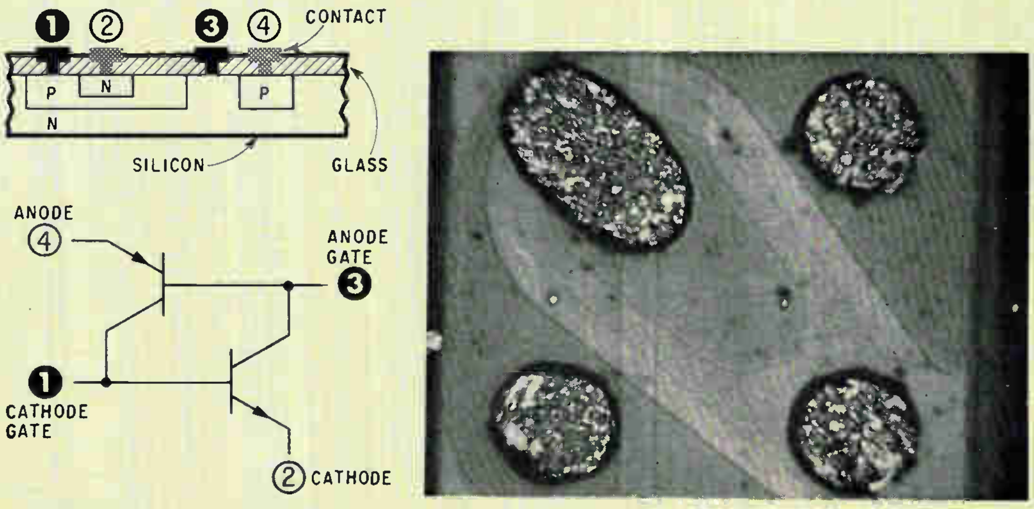
Beams. The most distinctive of the face-bonding methods is the beam-lead technique under development at the Bell Telephone Laboratories, Inc. [Electronics, Nov. 16, 1964, p. 114]. Thick, gold extensions of the thin-film terminals of the semiconductor devices or circuits are electroformed so they extend beyond the edges of the chips.

How far development has progressed is seen in the photo of a strip of transistors. Similar strips could be fed into automatic bonding machines much like a roll of postage stamps. The devices would be clipped apart as they were bonded unless, for example, the circuit called for transistors with common electrode connections.

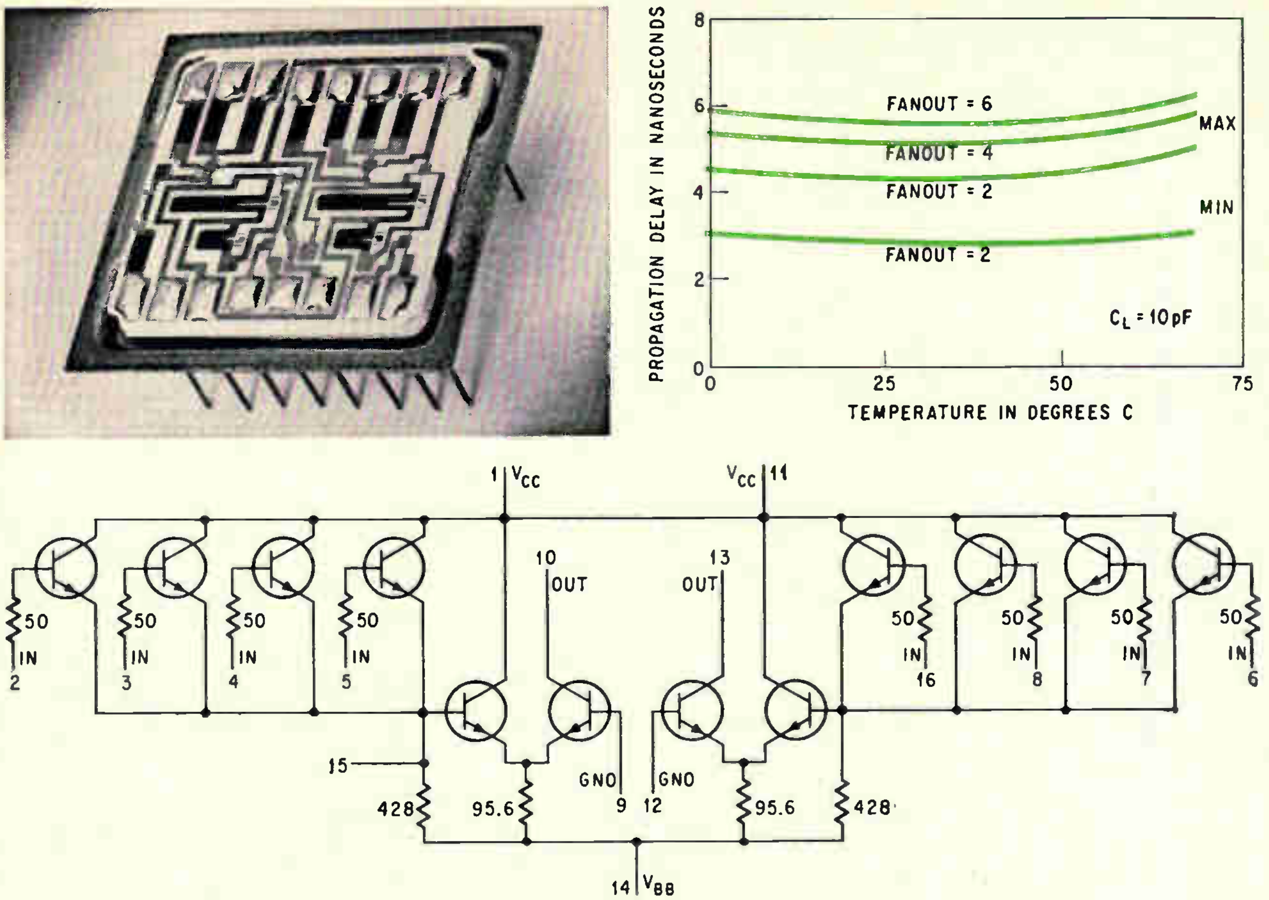
While Bell Labs declines to speculate on future ramifications of beam-lead structures, it appears obvious that large numbers of beam-leaded devices could be produced as interconnected arrays. Faulty components — there are always faulty devices mixed among the good ones on the parent slice of silicon—probably could be clipped out and good ones attached by beam-to-beam welds. Likewise, a variety of circuits might be welded into an array, or pnp parts made by one process added to npn parts made by another.

Approaches that make chips easier to handle, such as the beam leads, appeal to hybrid-circuit manufacturers because of the difficulty of handling the tiny conventional chips during assembly. However, the method is a controversial subject among integrated-circuit manufacturers because the beams take up much "real estate" on the silicon wafer and make the circuits more costly to produce. Systems manufacturers counter that chip costs are negligible compared to assembly, test and packaging costs.

However, face-bonding is not a panacea. Packaging engineers point out that die-bonding (soldering the chip to the substrate) cools the chip better. The thermal contact between the silicon mass of the chip and the substrate is far larger than the thermal contact provided by the face-bonding pads. Die bonding will still be preferred for devices that must dissipate large amounts of power, until simple, effective methods of heat-sinking face-bonded chips are developed.



Bump-contacted chip. In this one, npn and pnp transistors share contacts 1 and 3. Photo shows top of chip. Large bump orients chip.



Dual four-input gate circuit, schematic and propagation-delay characteristics. While the schematic shows eight individual transistors being used with the eight input resistors, the actual circuit has a single multiple device in each input section. Note the tailoring notches and guide marks at the precision resistors.

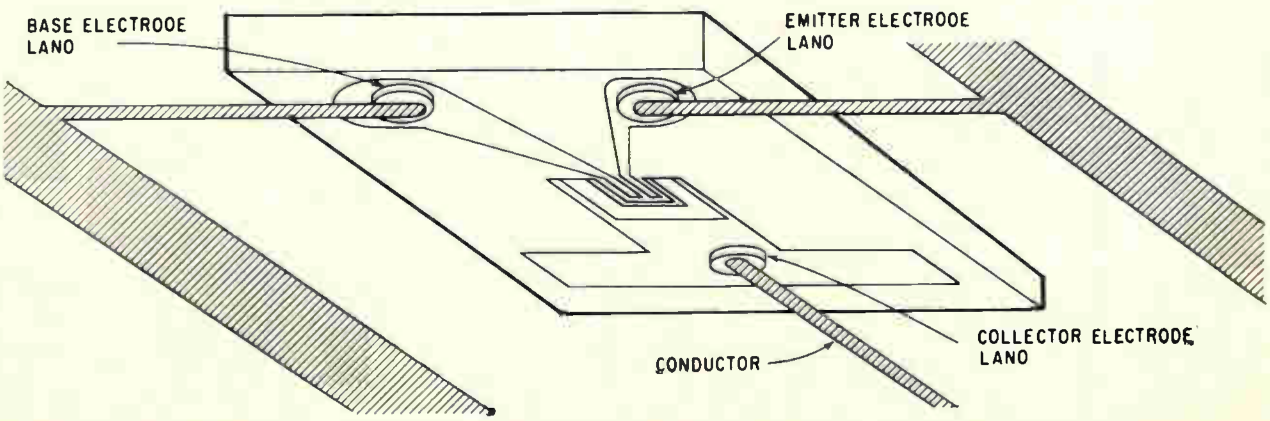
The contact points on the terminals of the devices are thickened by the electroding console, which can handle any wafer geometry. The wafers are then diced into device chips.

Chips are tested for device characteristics by an orient-and-test console. It aligns the lands, makes electrical tests and stores selected devices in magazines. The devices are stored with all lands in a predetermined position.

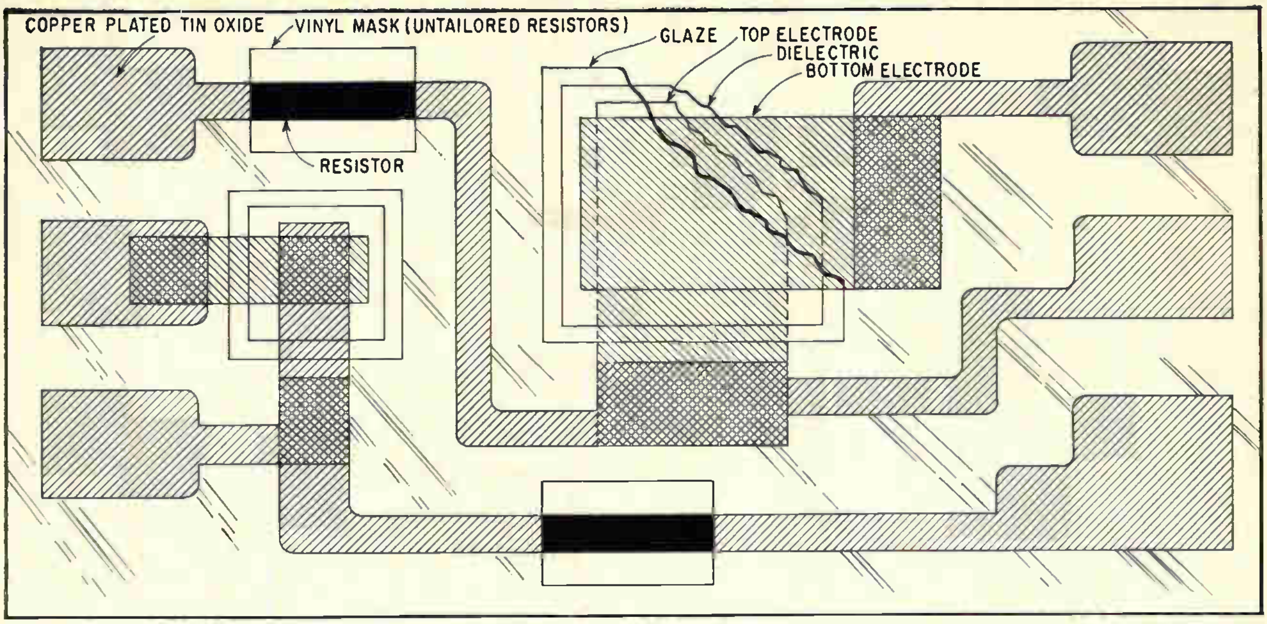
At the attachment station, a programed machine positions the substrates under bonding heads and selects required devices from an array of magazines. Each device is rotated to line up its lands with the conductor terminations on the substrate, is lowered into place and welded. Attachment doesn't alter device characteristics.

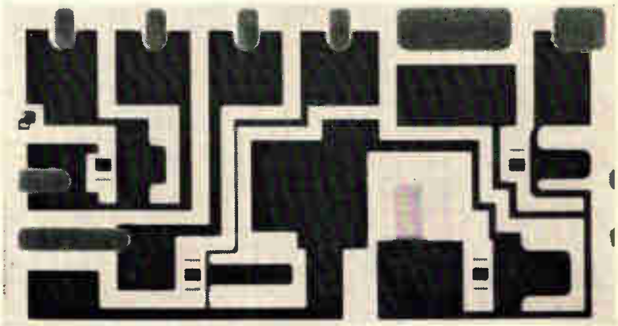
Bond strength is unusually high—devices regularly withstand a force equivalent to 375,000 g. If required, chips can be removed and replaced without sacrificing bond strength. This capability is especially valuable when constructing functional blocks containing many devices.

Face-bonding chips being made by Corning include high-speed npn switching devices for cur-



Face-bonded transistor, as it would appear if one looked up at it through a transparent substrate.





Capacitor construction and the method of masking resistors before copper plating is shown in the drawing. At right is a typical passive network before copper plating. The capacitor at the lower right is barely visible under the glaze. The bathtub shapes will become precision resistors.

rents from 10 to 60 milliamperes, quadruple npn's for current-mode logic gating, dual npn's for differential amplifiers and single and quadruple diodes. In design are high-current npn and pnp transistors for memory drivers and pnp devices to complement available npn's. Field effect transistors and complete monolithic integrated circuits can be obtained also. These devices, with varying speed, power and voltage levels, can be mixed or matched in a single circuit.

Substrates and capacitors

The substrates are alumina, chosen for its high thermal conductivity, which is similar to stainless steel's and 15 times better than glass's. Its job is to conduct heat from the circuit and provide physical strength. The film components are not made directly on the alumina, but on a glaze of alkali-free, aluminosilicate glass laid over the alumina. Standard substrate size is 1.7 by 2 inches, usually enough area for several circuits. The circuits may be packaged individually or as an array of circuits.

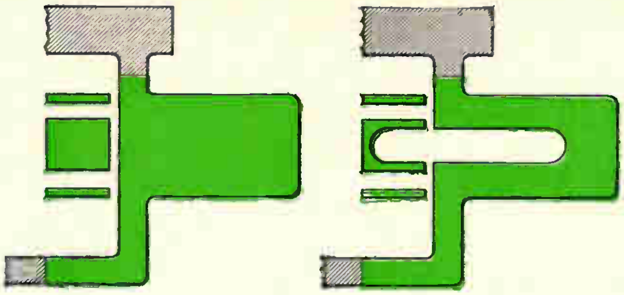
If a circuit requires capacitors, these are made first. The dielectric is of the same family of materials as Corning's Pyroceram glass-ceramics. It is principally a niobate glass and has a dielectric constant of 400.

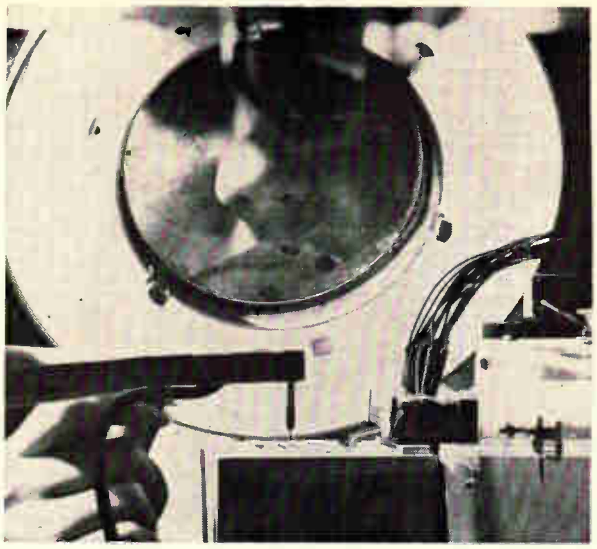
The dielectric is prepared as a frit, a paste of glass particles and binder which can be printed on the substrate through a metal mesh pattern. The method is known as silk screening or screen printing. The dielectric is applied about 1.7 mils thick between top and bottom electrodes of screen-printed gold, such as du Pont 8067 gold paste. As a hermetic seal, a layer of aluminosilicate sealing glass is applied over the entire capacitor, leaving only the electrode ends exposed.

A high-temperature firing process devitrifies the dielectric, binds the materials to each other and to the substrate, and seals the capacitor. During the remainder of the circuit processing, the capacitors are treated as if they were part of the substrate. Temperature cycling up to 650°C has little effect on them and the hermeticity of the glass seal is not affected by subsequent chemical processing.

Capacitance density is approximately 80,000 picofarads per square inch of active area, the area of dielectric sandwiched between the electrodes. Typical d-c working voltage is 50 volts. Further details on construction and performance of these capacitors are shown above and on page 72.

These film ceramic capacitors can be used as bypass, speedup, tuning, blocking or coupling capacitors. The extremely short, low-inductance terminations maintain bypass efficiency, hence fewer and cheaper capacitors are needed and circuitry is quieter and more trouble-free. Capacitors may be





Resistor-tailoring technique. While this is a standard procedure, the way Corning locates the adjustment notch in the resistor is distinctive. The guide marks help align the abrasive jet (photo) in the center of the resistor and provide a visual quality-control check on how well the jet is centered during the tailoring process.

paralleled by having them share one common electrode and a single dielectric body.

Oxide-film resistors

The glaze on the alumina substitutes for the glass rod on which discrete tin-oxide resistors are made by spraying an oxide composition on the glass at high temperature. Characteristics of the film and discrete resistors are practically the same, but the film version is much simpler. The end caps, terminal wires and insulation of the discrete version are eliminated.

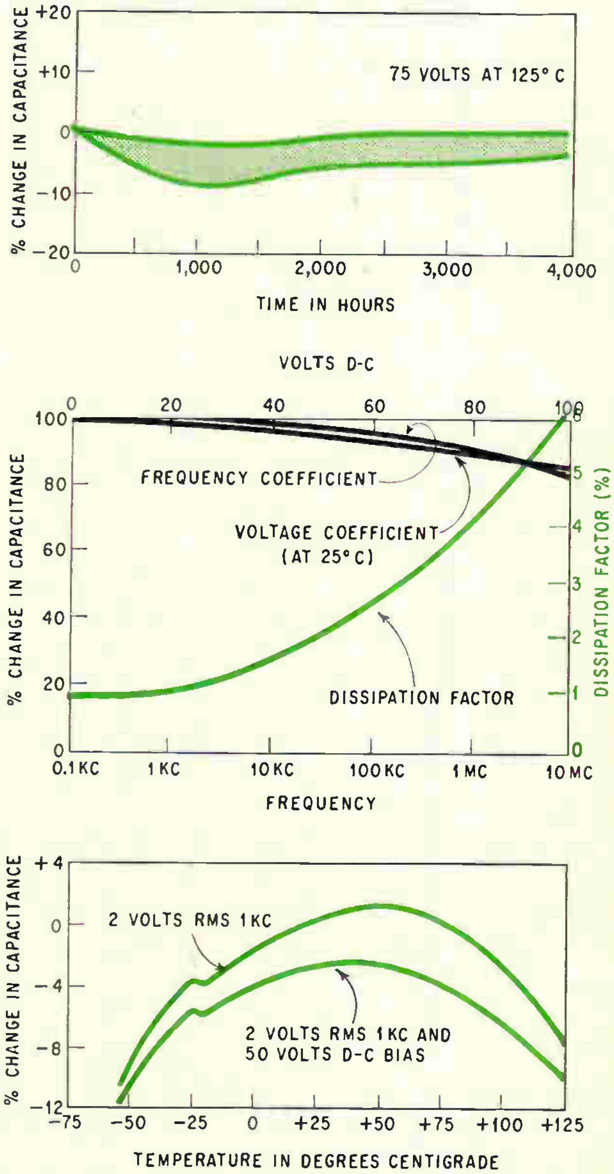
Film resistivity may range from 25 to 400 ohms per square. However, most thin-film circuits are constructed by applying a uniform coating of either the high or low value over the entire glazed-ceramic substrate.

Precision resistors are etched to a geometry that gives slightly less than the desired value, and then they are "tailored" to tolerances as close as ½% or as broad as 10%; 2% is usual. The tailoring consists of lengthening the resistive path, to raise the resistance value, by removing film with an abrasive jet. The procedure, often called "sandblasting," is shown above.

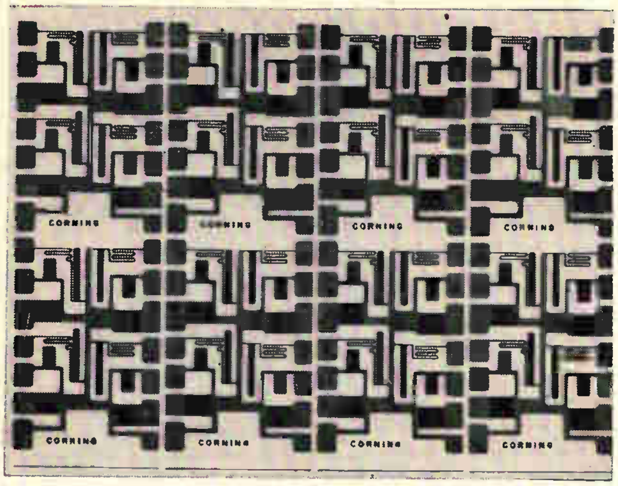
The adjustment is controlled automatically with the resistor in a bridge circuit. Two resistors of a circuit may be closely matched by using a special switching arrangement during tailoring. They will generally track better (vary equally in value during temperature changes) than discrete resistors, since they are both made from the same film on the same thermal base.

Excellent tracking is obtained by interdigitating meandering resistor paths. The photo on page 73 shows some meandering resistors. In this case, the narrow, looping lengths of oxide are high-value resistors and the tailoring resistors are in series with them.

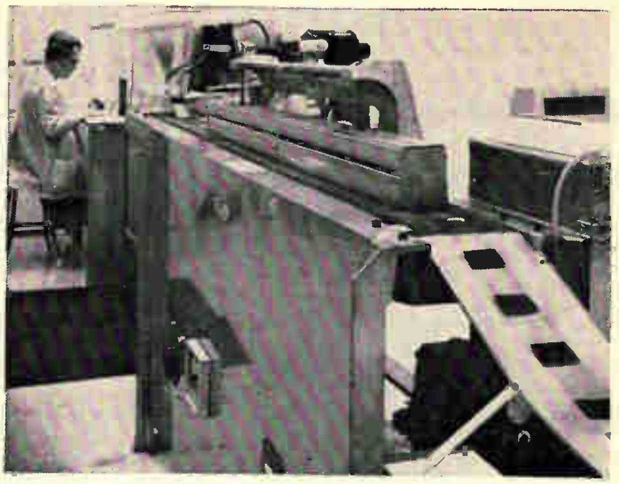
The resistors can also be tailored after the chips are bonded, while the circuit is actually operating, a feature that has proven valuable in such circuits as closely balanced differential amplifiers.



Performance curves for ceramic film capacitors: accelerated life test results (top), dissipation factor (color) and voltage and frequency coefficients (center), and temperature coefficients of typical capacitors.



After copper plating, resistor networks look like this. There are eight networks on the substrate.



Substrates on their way to the etching station. The tin oxide has just been coated with photoresist.

Resistor ratings

Power ratings of thin-film resistors must be determined indirectly since the thermal picture of a network is complex. Dissipation cannot be determined for individual resistors, but for groups of resistors having different shapes, locations and duty cycles.

Therefore, the substrate is rated for maximum rise above ambient temperature. Full rating for tin-oxide resistors is a 30°C rise above 70°C. A power rating of 2.5 watts per square inch is allowed on average substrates of 0.4 square inch. Power ratings of normal-sized resistors are limited to 200 milliwatts. Higher dissipations are handled with larger areas and supplemental heat sinking.

Some manufacturers rate resistors according to power density for a given resistor area. rather than substrate area. This will, of course. give a much higher value—in the range of 15 to 25 watts per square inch for tin oxide. But the criteria given above provides performance that closely parallels that of discrete tin-oxide precision resistors conforming to MIL-R-10509. Detailed resistor characteristics are published in literature available from Corning Glass Works.

Conductors and crossovers

Unique to the tin-oxide process is the way component interconnections are made. The oxide-coated substrate is patterned by etching, with the photoresist process, into the combined resistor-conductor geometry. The resistor areas are masked by a screen-printed film of vinyl. The interconnection pattern is made conductive by the electroless plating of copper, which plates only on the exposed oxide, not on the bare glaze of the substrate.

The ends of the gold electrodes of the capacitors are under the oxide. The gold-oxide-copper sandwich is really a resistor, but the oxide film is so thin resistance through it is negligible.

These techniques insure precise registration, essentially in a single step, of conductors with thin-film electrodes and with the bonding pads of the chip devices. Location of conductor terminations must be precise for face bonding and its automation to be practical. Conventional thin-film techniques require deposition and registrative patterning of each material used to make the components and conductors.

The capacitor production method, in addition, economizes on circuit design and production by enabling the designer to make conductor crossovers at little or no expense. When the capacitor electrodes are printed, gold stripes are also printed where a crossover will be needed. When the sealing glaze is applied to the capacitor, it is also applied to the midsection of the stripes. Later, the ends of the stripes connect two runs of copper, while a third run goes over the glaze.

At present, this is the preferred method for making crossovers. Another method is simply to use the glazed tops of the capacitors to run a conductor over the circuit path through the capacitor. Other film techniques generally require special deposition of an insulator, or a chemical process like anodizing to insulate the bottom conductor.

Packaging

Simple resistor and capacitor networks need only a conformal coating of silicone insulation for environmental protection.

The standard package for circuits with silicon devices is a one-inch-square, 16-lead metal can that is hermetically sealed by welding. Hermetic packages are fool-proof, but less expensive plastic packages can be used when the circuits are intended for industrial and commercial applications where environmental conditions are not severe. The chips are covered with silicone. Organic plastics form an outside case. As much glass and ceramic as possible is left bare, to minimize exposure of the plastic to moisture.

Organic materials are never perfect moisture barriers, but the moisture protection of these packages is often adequate.

Designer's casebook

Designer's casebook is a regular feature in Electronics. Readers are invited to submit novel circuit ideas, packaging schemes, or other unusual solutions to design problems. Descriptions should be short. We'll pay $50 for each item published.

Photocell triggers counting circuit

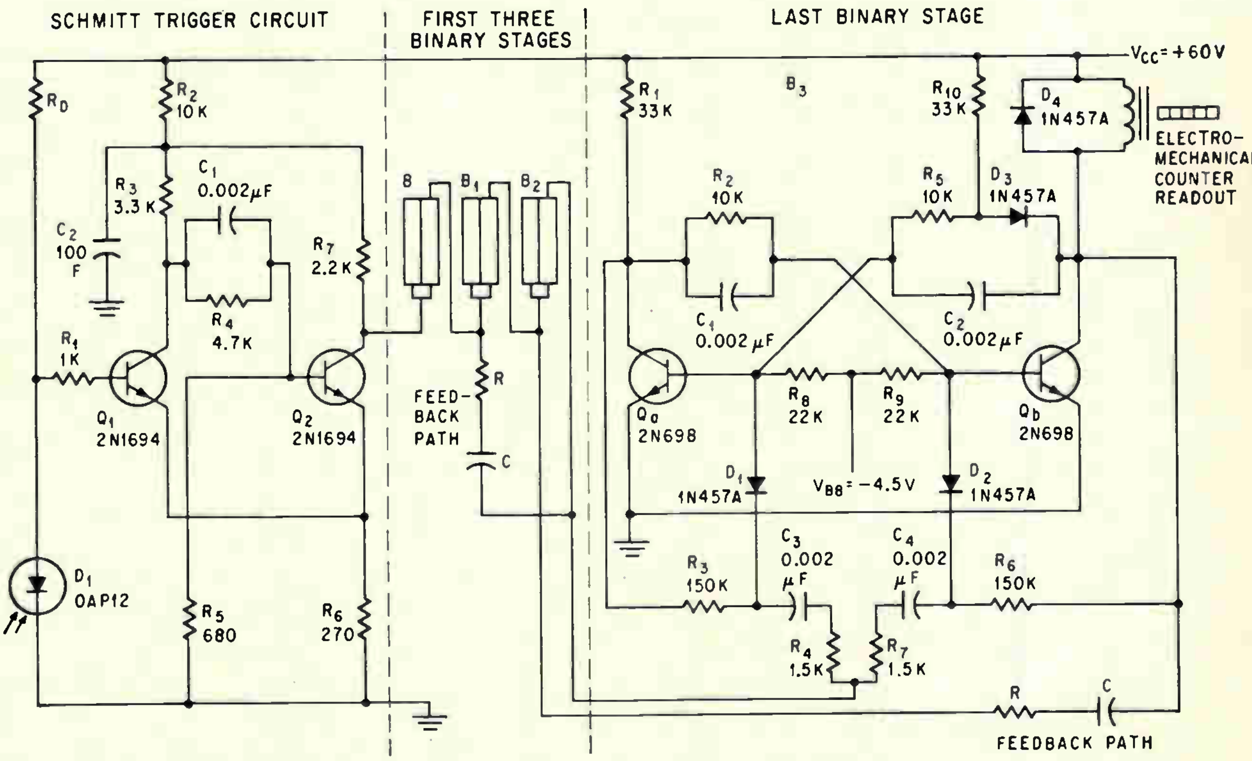
By E.J. Brach
Canada Department of Agriculture, Ottawa

Small objects such as beads, buttons, screws or agricultural seeds can be counted by the circuit shown below. The objects pass between a light source and the photodiode, one at a time, producing a voltage higher than the upper threshhold of the Schmitt trigger. Within a given range, the dimensions of the object can vary without affecting counting accuracy since the Schmitt trigger circuit delivers an output pulse with a uniform amplitude whenever the input signal is above the threshhold turn-on voltage—in this case 200 millivolts.

This circuit directly drives an electromechanical counter at a rate of 30 counts per second. With additional binary networks, the counting rate can be extended to 300 counts per second.

With the Schmitt circuit at quiescence, Q_1 is cut off and Q_2 conducts. The collector voltage of Q_1 is coupled to the base of Q_2 through resistor R_4. The base-to-emitter voltage of Q_2 is equal to the voltage drop across R_5 minus the voltage across R_6. With Q_2 conducting $V_{R6} > 0$.

A 200-millivolt pulse from the photocell causes Q_1 to conduct. The collector voltage of Q_1 falls, reducing the base current of Q_2 to a point where Q_2 is no longer saturated. The decrease in Q_2 collector current results in a decrease in V_{R6}, increasing the base current of Q_1. During this time, both transistors are active and the circuit is regenerative. This regenerative action continues until Q_1 is saturated and Q_2 is cut off. The circuit returns



Counter consists of a photocell, Schmitt trigger, four binary circuits in series, and an electromechanical counter readout. Each time the photocell is unblocked from its light source, the Schmitt trigger produces an output pulse that changes the state of the binary circuits.

to its initial state when the photodiode voltage falls below the lower threshhold, or the minimum trigger voltage.

The 5-volt output signal from the collector of Q_2 is fed to the first multivibrator of the decade system. Capacitor C_2 in the Schmitt trigger prevents the circuit from oscillating.

Only the last binary, or flip-flop, stage is shown in the circuit diagram. All the binaries are unclamped saturated multivibrators. The multivibrators can operate up to a maximum frequency of 1 kc.

The Q_a and Q_b circuits in the multivibrator are symmetrical.

To ensure that the on transistor is saturated, the following relation must be maintained:

$$\frac{V_{cc}}{R_1 + R_2} - \frac{V_{BB}}{V_8} > \frac{V_{cc}}{\beta R_1}$$

where $\beta = 30$ for the 2N698 transistor.

The multivibrator output voltage excursion is expressed by

$$V_{out} = V_{cc}\left(\frac{R_2}{R_1 + R_2}\right) - V_{Qa(SAT)}$$

In this circuit $V_{Qa(SAT)}$ is the collector to emitter saturation voltage of Q_a, and $V_{out} = 13.83$ volts.

The reverse bias on the collector-base junction of the off transistor is

$$V_{BE} = \frac{V_{BB}R_2}{R_2 + R_9} = -1.4 \text{ volt.}$$

Assuming Q_a is on and Q_b is off, enough current will flow through R_{10} and R_5 to forward bias the base of Q_a, saturating it. The R_2-R_9 divider reverse biases the base of Q_b, keeping it off. If an input signal is introduced, Q_b turns on and Q_a turns off.

Diode D_3 is reverse biased. It isolates the electromechanical counter from the circuit when Q_b is off.

Speed-up capacitors C_1 and C_2 are small enough to minimize the R-C time constant and at the same time large enough to provide sufficient trigger drive.

Because of the pulse steering diodes D_1 and D_2, pulses of the same polarity trigger the flip-flop on and off.

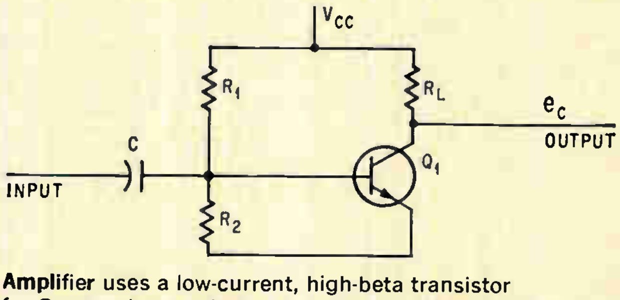
Resistors R_3 and R_6 are selected to minimize loading but at the same time allow the steering circuit to recover within one cycle.

The flip-flop changes stage when triggered by a pulse wtih an amplitude of 5 volts and a rise time of 15 μseconds at the junction of R_4 and R_7. Each binary voltage output is 14 volts. Coil resistance in the electromechanical counter is about 1000 ohms.

The electromechanical counter placed in the collector of Q_b, advances every 10th count, eliminating an additional relay-triggering circuit.

Amplifier gain is constant despite changes in load

By Richard C. Lavigne and
Leonard L. Kleinberg
National Aeronautics and Space Administration
Goddard Space Flight Center, Greenbelt, Md.



Amplifier uses a low-current, high-beta transistor for Q_1, as voltage gain that is a function of only the bias point if the supply voltage is constant.

An amplifier circuit that maintains almost constant gain despite wide variations in component values can be designed if the quiescent collector current is maintained constant with changes in the amplifier load or transistor beta.

Analysis of the basic amplifier in the schematic at right shows that the voltage gain is independent of the load resistance and is a function only of the supply voltage and the quiescent bias, if the following conditions are fulfilled:

- The a-c and d-c load lines are identical
- Low current, high-beta transistors must be used.

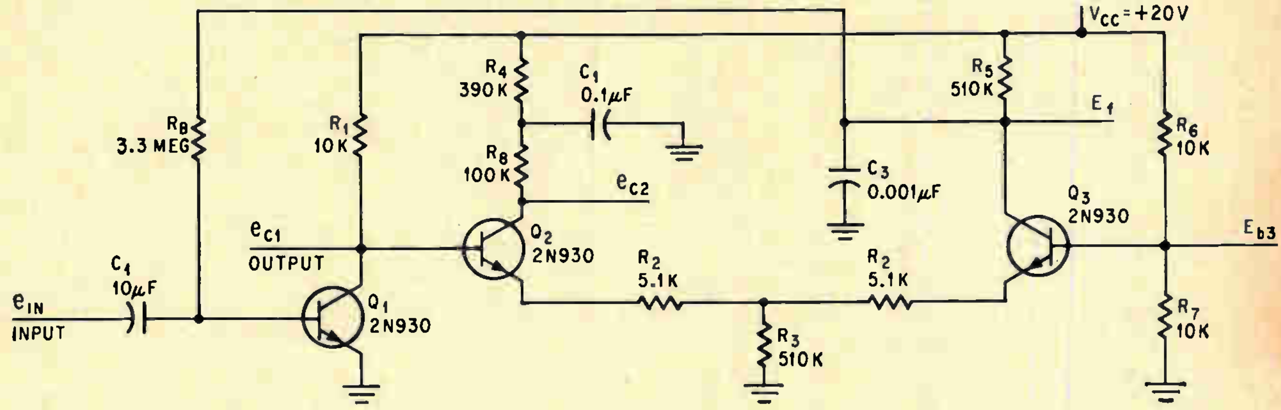
The voltage gain of this amplifier is

$$K_v = \frac{R_L}{r_e + (r_b + r_g)/\beta}$$

With low-current, high-beta transistors for Q_1, intrinsic base resistance r_b is usually small. Under these conditions, using a low source impedance r_g this equation reduces to

$$K_v = \frac{R_L}{r_e}$$

The quiescent collector current is equal to



Differential amplifier Q_2-Q_3 regulates bias voltage of Q_1 amplifier, which stabilizes its gain even though the load changes significantly.

$$I_c = F \frac{V_{cc}}{R_L}$$

where $F = \frac{V_{cc} - e_c}{V_{cc}}$ and is always less than one.

In a transistor, the emitter resistance as a function of emitter current is given by the diode equation

$$r_e = \frac{1}{39I_e}$$ where 1/39 has the units of volts.

Since $I_c \approx I_e$,

$$r_e = \frac{R_L}{39FV_{cc}}$$

This value of r_e is substituted in the simplified gain equation to obtain

$$K_V = 39FV_{cc}$$

which states that the voltage gain is independent of load—it is a function only of supply voltage and operating point. For constant gain, then, it is necessary to maintain a constant operating point.

To determine the validity of this equation, the circuit shown was tested with V_{cc} = 16 volts and R_L varied from 100,000 to 600,000 ohms. A constant F = ½ was obtained (e_c = 8 volts) by adjusting the resistances of R_1 and R_2 for each value of R_L tested.

Different samples of high-beta transistors (2N930 and 2N338) and low-beta types (2N335 and 2N333) were used for Q_1. Results show that the equation is only valid for high-beta transistors.

Assuming constant supply voltage, the gain is a function of F, or the quiescent voltage. But in simple amplifiers the quiescent point may vary because of changes in beta or circuit component values.

The gain of the amplifier in the circuit diagram above is held constant because its quiescent collector current is constant. This circuit is capable of producing very high gain.

The voltage gain of Q_2 is

$$K_v = \frac{\frac{R_8}{2R_2}}{1 + \frac{R_8}{2R_2(39FV_{cc})} + \frac{R_1}{2R_2\beta}}$$

The collector voltage of Q_1 is compared with the base voltage of Q_3 by the Q_2 — Q_3 differential amplifier. Any difference between these is amplified and appears at the collector of Q_3. The amplified voltage difference biases Q_1.

If the gain is high ($R_5/2\,R_2 > 50$), the difference between e_{c1} and E_{b3} will be small and the quiescent point will remain constant with changes in beta and load.

In the Q_2 circuit, $2\beta R_2$ must not load down R_1, so that the gain for Q_1 will not depart significantly from $K_v = 39\ FV_{cc}$.

The collector of Q_3 is bypassed to avoid a-c feedback.

The gain stability can be determined from the following analysis. In the Q_1 amplifier, $e_{c1} = V_{cc} - \beta I_b R_1$ and $I_b = E_f/R_B$
therefore $e_{c1} = V_{cc} - \beta E_f\, R_1/R_B$. By differentiation

$$de_{c1} = -\frac{E_f\beta\, dR_1 + \beta R_1\, dE_f + E_f R_1\, d\beta}{R_B}$$

The gain of the differential amplifier $K_{DC} >> 1$ and $dE_f = K_{DC}\, de_{c1}$. With these values substituted into the equation above,

$$de_{c1} = -\frac{E_f}{K_{DC}}\left[\frac{d\beta}{\beta} + \frac{dR_1}{R_1}\right]$$

For the simple amplifier with constant supply voltage, the gain varies as the quiescent point $dK_v = 39\ V_{cc}\ dF$, and $dF = -de_{c1}/V_{cc}$
Substituting these into the equation above and dividing the left side by K_v and the right by $39\ V_{cc}F$,

yields

$$\frac{dK_v}{K_v} = \frac{E_f}{FV_{cc}K_{DC}}\left[\frac{d\beta}{\beta} + \frac{dR_1}{R_1}\right]$$

Now, suppose β and R_1 each changes by 50%. If the output voltage is designed so that $E_f \approx FV_{cc}$, the relative change in gain will be $1/K_{DC}$—in this case, only about 2%.

The most critical component value in designing the amplifier is R_B. Its value must be such that Q_3 neither cuts off nor saturates.

This amplifier was built and tested. The a-c gain at e_{c1} was reduced by only 6% when the value of the load resistor R_1 was doubled. This reduction was due to the increased loading effect of Q_2's input impedance, causing Q_1's a-c load line to deviate significantly from its d-c load line. To keep the a-c gain from changing with wide changes in load, the input impedance of Q_2 should be sufficiently large with respect to the highest value of R_1.

An auxiliary output exists at e_{c2}, which is not in the gain-controlled loop. It may be used, however, as a high-gain amplifier in an automatic gain-control (agc) loop to vary the gain of Q_1.

The gain of Q_1 varies linearly as the reference voltage E_{b3}. In the breadboard circuit, V_{cc} was doubled; the a-c voltage gain at e_{c1} varied linearly over this range.

With the option of two outputs—e_{c1} and e_{c2}—and two gain-controlled inputs—V_{cc} and E_{b3}—the circuit has applications as a modulator, demodulator, temperature-stable high-gain amplifier, multiplier or a divider.

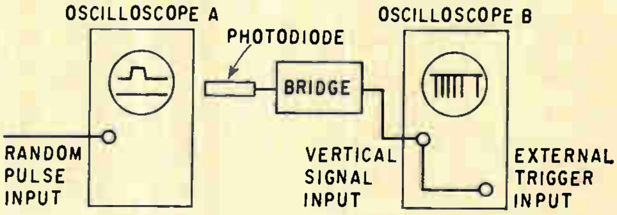
Pulse frequency measured by photoconductor and scopes

By Ian Baird

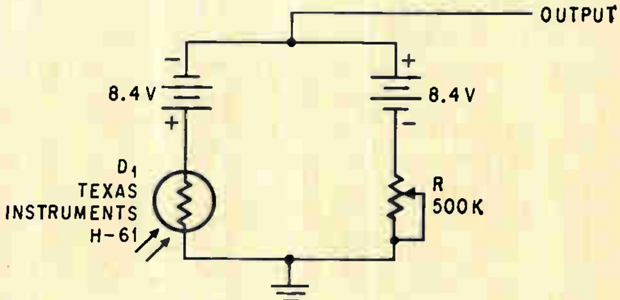
Columbia University, New York City

In a series of pulses whose amplitude and period vary randomly, the frequency of those pulses larger than a certain amplitude can be determined simply with a pair of oscilloscopes.

As shown in the diagram at right, a photoconductor is placed directly opposite the screen of oscilloscope A. This scope, which receives the random input, is adjusted to trigger itself at a minimum pulse amplitude. A pulse on the screen of scope A illuminates the photoconductor, which is connected as one leg of a bridge circuit. The bridge becomes momentarily unbalanced when the pulse occurs. The bridge output is the vertical input and also the external trigger for oscilloscope B. Therefore, the bridge output appears as a blip on oscilloscope B.



Oscilloscope A is adjusted to trigger a sweep at the voltage level of selected pulses whose frequency will be measured. The waveshape is displayed on the scope for each pulse amplitude equal to or greater than the trigger level. The waveshape display illuminates a photoconductor in the detector circuit, which causes a blip to appear on oscilloscope B. Average frequency of these blips is the average frequency of the selected pulses, and can be determined by counting the number of blips per sweep period.



Detector circuit becomes unbalanced when a light from pulse waveshape displayed on scope A illuminates the photoconductor.

The sweep of scope B is triggered when it receives a pulse from the bridge, which may also be considered a detector circuit. Sweep speed on oscilloscope B is adjusted so that the blips on its screen can be conveniently seen and counted. The average frequency can be determined from

f_{avg} = Number blips per sweep/Sweep speed

Due to fluctuations in brightness of the selected pulses displayed on scope A, illumination of the photoconductor and blip amplitudes on scope B will vary. A second trace of constant intensity, having the same time base as the random pulse display on scope A, may be used to excite the photoconductor to provide constant detector output.

Variable resistor R balances the detector at quiescence and also is a sensitivity control. Maximum sensitivity is obtained when R is adjusted to equal the d-c resistance of the photoconductor under ambient light conditions.

Low light tv sees in the dark better than the human eye

All branches of the military are looking at systems that don't even need starlight to pick out the enemy

By W.J. Evanzia
Avionics Editor

The two pictures on the opposite page would never win a prize in a photography contest, but they might show how to win a battle. The photo at left, taken in dim light with an ordinary tv camera, shows an innocuous and apparently uninteresting patch of woods. That those woods are both interesting and dangerous is proved by the picture at right.

The tank's presence was betrayed by a low light level tv system using a red filter with a General Electric Co. image orthicon. The tube, which has a photocathode sensitive to the wavelength of visible light—0.38 to 0.8 microns—is however, ten times as sensitive as the human eye. GE claims that the tube has a resolution of 300 tv lines at 10^{-6} footcandles.

Since starlight alone is about equal to 10^{-4} footcandles, it is clear that low light television offers great promise to the military. And in fact all three services are studying such systems. Researchers at Wright-Patterson Air Force Base in Dayton, Ohio, are particularly interested in low light tv for counterinsurgency aircraft.

The Navy wants to use low light tv as a support for night marine landing operations, shore bombardment and artillery spotting. It is already using an image intensification system to aid night landings on carriers. The Pilot Landing Television system (PLAT), is an image intensifier coupled to an orthicon tube; deck officers use the system as a nighttime landing aid. The Ampex Corp. in Redwood City, Calif. has delivered 25 PLAT systems.

Army engineers at Ft. Belvoir, Va. are now engaged in research in low light level amplifying devices. These devices vary from image intensifiers which clip on to rifles, to more sophisticated squad transported television systems.

The clip-on image intensifier [Electronics, April 20, 1964, p. 32] consists of a glass membrane coated on the inside with a silver oxide-cesium film containing several additive materials. When struck by photons, the film emits electrons into an evacuated tube. Here a ring-and-disk system of electron optics creates a magnetic field to focus the electrons on a green-white phosphor screen and form the target picture. The intensifiers are being made by Machlett Labs. in Stamford, Connecticut.

Flying tv camera

The Radio Corp. of America's Aerospace division at Burlington, Mass. is working on several low light level tv systems. One of these, a night visual search and tracking sub-system, is designed for aircraft operation at from 500 to 5000 feet, at speeds up to 300 knots. In-flight evaluation of the engineering model began on May 24 of this year. Although designed primarily for use aboard fast reconnaissance planes, it can also be used aboard slower propeller types—such as the Cessna 310 —or on helicopters.

The RCA camera is mounted in an X-Y gimbal system, which permits the camera to be rotated ±70 degrees and elevated from −30 degrees to +5 degrees. The camera assembly contains the lens, tube, and all the electronics, including the high voltage supply for the tube, the synchronization circuits and deflection coils. The only external connections on the camera assembly are video and sync outputs, which feed a 5-inch kinescope with a red filter in front of the pliot, and a larger, 14-inch display for the observer. The camera also provides positional error information for the automatic tracking circuits.

Removing smear

When television cameras are mounted on high-speed aircraft, they are subject to the same motion problems that beset other reconnaissance cameras. Especially troublesome is picture smear, which is due to the relatively high angular rate of change

The value of low light level television is shown clearly by these two photographs of the same patch of woods. Picture at left is a Polaroid snapshot of the image produced by an ordinary tv camera at dusk. The woods appear almost inviting. But the photo at right, taken of the same screen when a GE low light image orthicon with a red filter was producing the signal, tells an entirely different story. The GE camera, now in prototype production, operates over an illumination range of 10^9 footcandles (10^4 to 10^{-5}). The latter level is dimmer than starlight, which is about 10^{-4} footcandles; and the camera has detected images at a level of 10^{-7} footcandles, which to the ordinary soldier is pitch blackness. Another example of the GE orthicon is shown on page 82.

between the aircraft and a point on the ground. For example, the rate of change a plane flying at 300 knots at an altitude of one mile is about one radian per second. Therefore, a new image appears on the picture tube target before the old one is completely erased. This problem is solved in some airborne camera systems by moving the film at an angular rate equal to that at which the plane is passing over the ground. The problem is more difficult in a forward-looking tv system, however, because each horizontal scan line requires a different amount of image motion compensation.

Automatic tracking circuits have been designed to reduce smear in such system [Electronics, May 3, 1965, p. 32]. In the RCA system, the observer manually locks the camera's tracking circuits onto a particular target of interest in his field of view. The tracking controls then regulate the position of the gimbals. With this technique, target smear is practically eliminated.

Light intensity

Low light level television systems must be able to take pictures anytime between twilight and dawn, during which the light level may vary between 10^{-1} and 10^{-4} footcandles.

In the RCA system, the average level of the video output from the tube is fed back as a control signal to change the voltage on the intensifier section of the tube, thus increasing or decreasing the light output as required. However, this is a scene-to-scene type of control, and there still remains the problem of variation of light intensities within each individual scene. At times, lighting contrast may vary as much as 1000 to 1.

The system has 525 scanning lines and a video bandwidth greater than 10 megacycles. The frame rate is standard (30 frames per second), and the operator has the option of operating the set in either an interlaced or noninterlaced mode. (In interlaced scanning, the odd and even-numbered lines of a picture are transmitted consecutively as two separate fields. These are superimposed to create one frame, a complete picture, at the receiver. The effect is to double the apparent number of pictures and reduce flicker).

Looking around

The tv optics must not only capture as much light reflected from the targets as possible, but also provide the best possible field of view. Because reconnaissance tv cameras would need the ability to "see" wide areas as well as focus on particular targets, RCA engineers conducted a series of experiments to determine the optimum systems requirement. They found that a lens with a 4 to 1 zoom ratio, varying the field of view from 28° to 7°, provided the highest over-all detection capability.

Few controls

The RCA system has only three manual controls: a system on/off switch, a display brightness control, and a hand-held positioning control for the tracking gates on the target acquisition display.

The hand-held control operates in two modes, manual and automatic. When the switch is pressed, the first mode—acquisition—allows the camera

Gun mounted image intensifiers help soldiers to see in the dark without revealing their presence.

gimbals to be moved manually so that the operator can electronically superimpose the cross-hairs of the tracking gate over the target on the display. When the button is released, mode two—automatic tracking circuits—take over and continuously point the camera at the target.

Choice of tube

No tube yet exists that satifies all detection requirements. RCA has designed its system to accept either of two tube types. Both, they say, look promising.

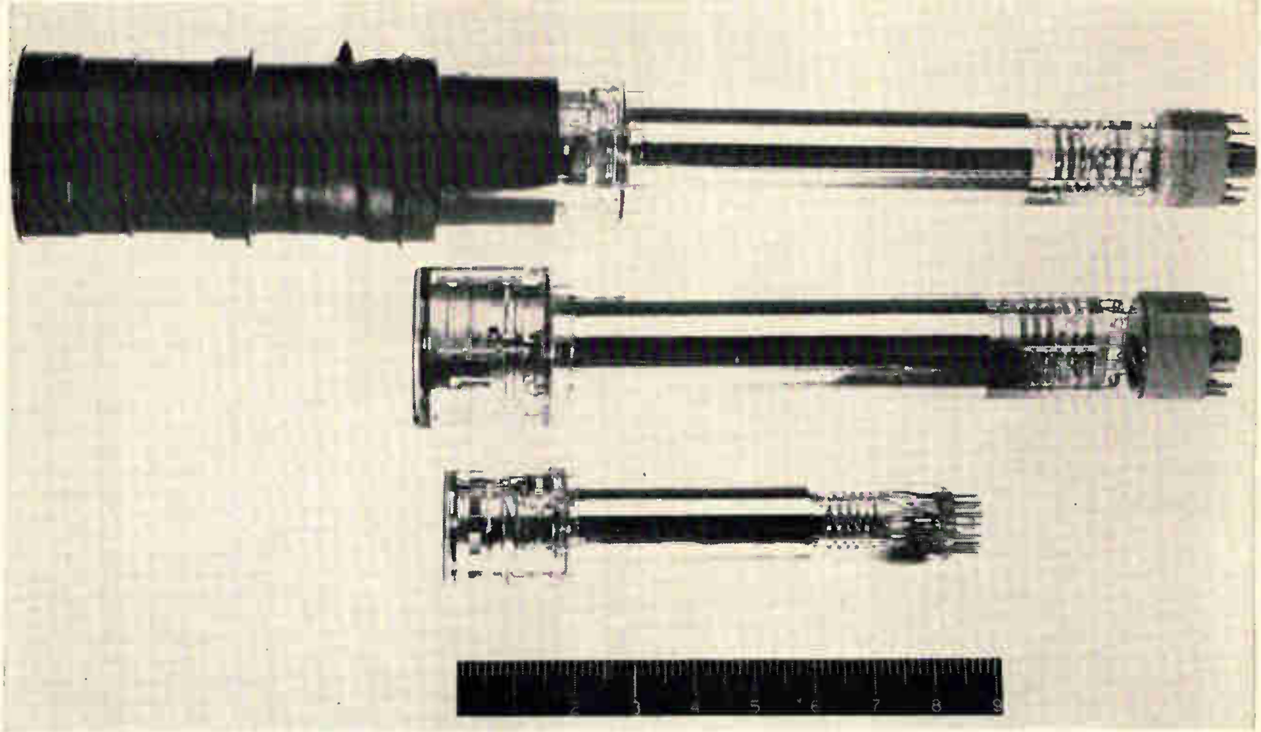
One is the SEC (Secondary Electron Conduction) vidicon; the other is the intensifier squared vidicon (I^2V). The SEC vidicon has less promise for military applications because its sensitivity is typically only 10^{-3} foot candles, although it does have the fastest erasure speed. But because the SEC vidicon is easily packaged in small, compact units, it has been chosen as the tv camera tube for the lunar explorers in the Lem module.

The SEC vidicon contains an S-20 photocathode, a target of aluminum oxide and potossium chloride, and a standard vidicon gun. Magnetic fields are used to focus photoelectrons and reading beam electrons onto the SEC target as well as to deflect the reading beam.

Photoelectrons having an energy of about 10,000 electron volts penetrate the AL_2O_3 and dissipate their energy in the KCl, creating low-energy secondary electrons. This differs from standard vidicon operation in that conduction through the target is achieved by free electrons rather than controlled electrons in the conduction band.

Stacked intensifiers

The I^2V has two electrostatically-focused intensifier units, each with a gain of 40, stacked in front of the tube. A target—especially a camouflaged target—may exhibit little contrast against its background. The intensifier-tube combination increases the signal-to-noise ratio, resulting in higher detec-



Three image orthicons made by RCA for low light level tv. The bottom tube is a 2-inch model, the middle a 3-inch tube, and the top a 3-inch tube fitted with a two-stage image intensifier section.

All the circuits for RCA's airborne camera are contained within the same tubular shell that houses the tv tube.

tion and resolution capability.

To minimize loss, fiber optics transmit the light from the intensifier to the vidicon. With this technique, system resolution is only degraded about 5%, while the system as a whole is 300 times more sensitive than vidicons without intensifiers.

Tube comparison

In performance, the SEC falls short of other vidicon tubes. It does not have the ability to detect targets at light levels of 10^{-4} footcandles with a sufficiently high signal-to-noise ratio to make the information usable. At such levels, objects with poor contrast to their background are lost; further, if a scene's illumination is of the order of 10^{-4} lumens per square foot, the reflected light is only of the order of 10^{-5} foot-lamberts.

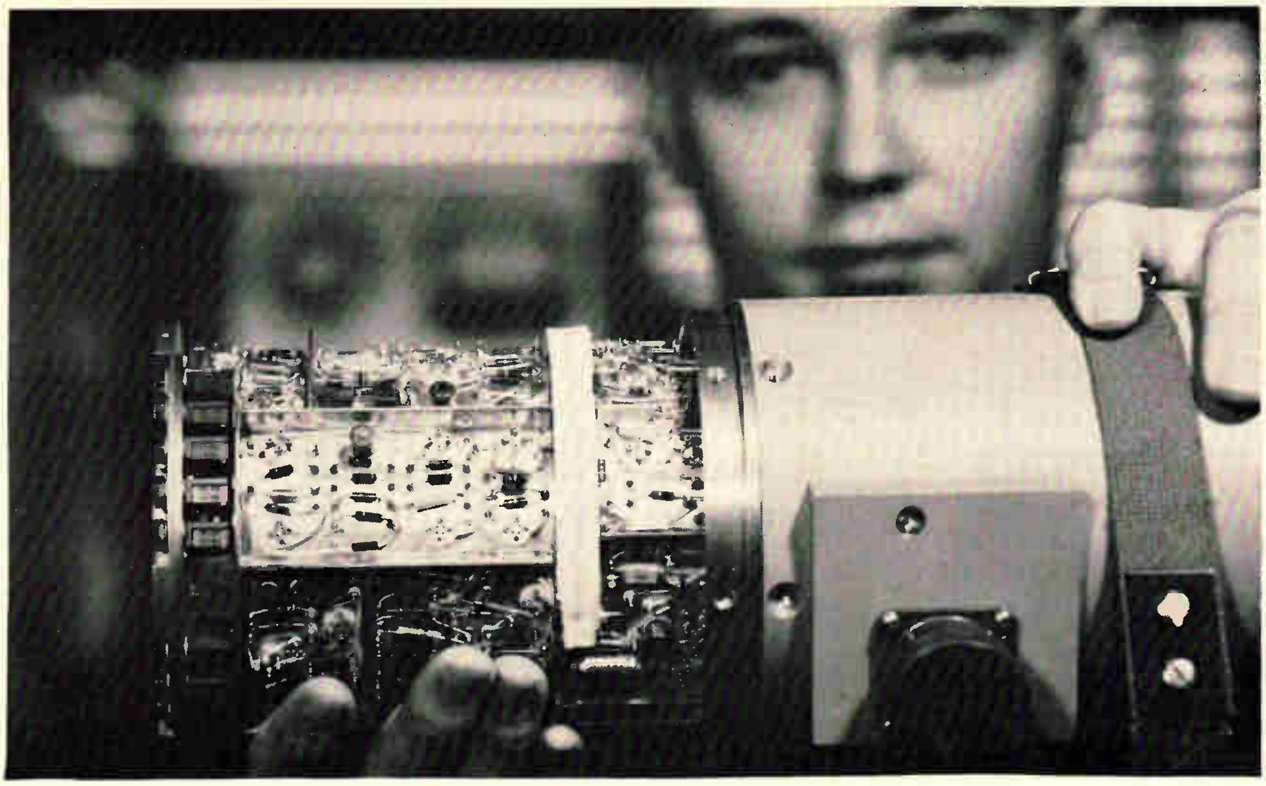
Orthicons are about a thousand times more sensitive than vidicons, but are not as rugged. Orthicons cannot be operated while vertically mounted, while vidicons are unaffected by position. Orthicons are larger, and require heavier, more unwieldly mounts than vidicons, and need more complex adjustments. In addition, the orthicon is more sensitive to temperature variations. For these reasons, vidicon tubes are preferred by the military. Intensifier vidicons can operate at light levels as low as 10^{-4} or 10^{-5} foot candles.

Image squared orthicon

RCA is working on an image squared orthicon, which like the I^2V, is used with two image intensifiers. RCA expects an I^20 tube to be able to detect light levels of 10^{-9} lumens per square foot.

RCA has also succeeded in combining an image intensifier with a vidicon in the same envelope. This means a system with inherently higher sensitivity and ruggedness, better resolution and less transmission loss.

The RCA airborne camera, with its lens and all of its electronics (excluding displays and tracking circuits), fits into a package 4 inches in diameter



GE engineer makes final adjustments on the control circuit for a low light level camera.

and 18.5 inches long and weighs only 17 pounds. The camera uses both discrete components and integrated circuits.

Automatic beam control

The GE system, now in prototype production at the company's Light Military Electronics department in Utica, N. Y., uses a unique intensity control and a new, more sensitive, image orthicon. The control, called automatic beam control (ABC) [Electronics Feb. 22, p. 46], combined with automatic filter control, enables an orthicon camera to be operated over an illumination range of 10^9 (10^4 to 10^{-5}) footcandles. The tube can detect light levels as low as 10^{-7} footcandles.

Designed as a wide band servo amplifier with high dynamic range and a 200 nanosecond response, the automatic beam control varies the intensity of the readout electron beam as it sweeps the target. Ordinary orthicons have a practical dynamic range (measured at the target) of about 26 db; this is increased to approximately 78 db

Another example of the General Electric Co low light level tv in action. The faint ambient light in the photo at left was necessary to take the picture. The shot above shows how the model looks on the monitor.

by the automatic beam control circuitry.

The intensity control improves the latitude of the system (range of brightness above and below the average that the tube can accommodate). ABC minimizes fading, protects against jamming from extraneous light, and may eventually make possible a fully automatic camera.

Preventing 'bloom'

The output signal from the image orthicon is sampled by a computer logic circuit to establish a reference voltage, which is a measure of the instantaneous charge on the camera's target. This in turn is used to adjust the readout beam current for optimum erasure between frames. If the beam current is not large enough for complete erasure, the charges will build up on the target from frame to frame, and eventually spill over others parts of the image. The result is washed-out and sometimes completely obliterated picture. This effect, referred to as "blooming", is minimized because the readout beam continuously follows a preset curve (optimum for low and high light levels).

Television cameras are extremely sensitive to sudden spots of bright light. Were the camera adjusted to accommodate these bright lights, much detail in a scene would be lost; and if the camera were adjusted to compensate for the darker areas, the bright spots would bloom and obliterate the picture information. Latitude adjustment is usually performed by a studio cameraman on a scene-to-scene-basis. Now the fast response time of General Electric's automatic beam control makes point-to-point brightness control automatic.

Arrow in the dark

The human eye could not see a white arrow suspended by a black thread in an almost pitch black room, even after 30 minutes of adaptation. But photons emitted by the arrows are easily picked up by the orthicon's S-20 photocathode.

The photocathode releases electrons that travel part way down the tube, strike a sensitive magnesium oxide target, and form the image of the arrow on the target's surface. Each electron that hits the target releases 10 to 15 more electrons from the target material. Meanwhile, the image which has been formed on the target is being swept by an electron beam from a gun in the neck of the tube. An electron multiplier intercepts the return beam and amplifies it a thousand times. Additional video gain of 1000 is provided in circuits following the electron multiplier.

As the orthicon's beam sweeps across the target image, the intensifier of the moving spot is controlled by a grid (in front of the target) which is regulated by the automatic beam control. This feedback loop senses the demand for more or fewer electrons; and since it has a response time of 200 nanoseconds, it is able to control light intensity at any position of the beam as it sweeps the screen.

As the video signal emerges from the ABC circuitry, it is sent to conventional automatic gain control circuits. Then the picture is displayed on a monitor that may be an integral part of the camera system.

Circuit timing is provided by a sync generator, or clock. The generator triggers horizontal and vertical sweep amplifiers for deflecting the beam in the camera tube. The sync generator also triggers a blanking generator that supplies horizontal and vertical blanking signals to both the tube and video processor during the retrace cycle. Horizontal and vertical sync drive signals are also provided by the sync generator to the monitor for non-composite video operation (picture signal, blanking and synchronizing signals separate). A composite video output is provided where direct horizontal and vertical drive is not desirable.

Compact electronics

A cylindrical shell about 5 inches in diameter and 28 inches long (with optics) and weighing about 27.5 pounds houses the video electronics and image orthicon. The power converter, sync generator, vertical sweeps, and filter programer are housed in a separate control unit. The control unit also has the manual controls required for initial alignment.

At present, the prototype sets use discrete transistor circuitry exclusively, although studies to incorporate integrated techniques are under way. The image orthicon is suspended in the center of the cylinder with the front (optics and intensifier) exposed through the forward vertical wall. Resistors, capacitors and transistors are wired point-to-point on component boards, which wrap around the tube. Power supply and video output connections are made through the side of the cylinder. Another design using integrated circuits in TO-5 cans is being developed for airborne and space applications.

Tv in space

Low light level television has applications other than purely military; it is also scheduled for testing on Gemini flights in 1966 and 1967 [Electronics, April 5, p. 106]. During orbital flights, astronauts pass from darkness to daylight about 30 minutes. Low light level tv can relieve their eyes of the strain of becoming light- and dark-adapted, since the tv monitor will provide an image of constant illumination. Further, the camera lens will actually see more than the astronaut's unaided eye.

For the battlefield, low light level tv has been thought of as a counterinsurgency weapon. It can complement the tactical radar systems now under development [Electronics, May 17, p. 103]. In the air, it can be useful for both reconnaissance and strike missions. For the military, which can never know too much about where the enemy is and what he is doing, the low light level systems may get the highest tv ratings of all.

Measurement of stored charge in diode clearly defines switching speed

New technique provides direct, accurate reading, eliminates ambiguities and complexities of method employing reverse recovery time

By T. Peter Sylvan
General Electric Co., Syracuse, N.Y.

The development of faster diodes to meet the needs of high-speed logic circuits has increased the problems of measuring and specifying diode switching speeds. The present method is based on the reverse recovery time of a diode—the time required for the reverse current to decay to 10% of its original value after the diode is turned off. Measuring reverse recovery time, however is a complex task that requires expensive sampling oscilloscopes; and the results exhibit poor reproducibility—that is, the test cannot be repeated with any assurance that the same results will be obtained.

The stored charge on a diode offers a better standard for determination of switching speed. This charge acts as a barrier to current reversal, and its measurement yields a number that can serve as an index of the diode's speed: the larger the charge, the slower the speed. The charge can be measured directly, with inexpensive equipment, and the measurments are highly reproducible.

Minority carrier charge

The forward current in a semiconductor diode is carried by minority carriers, either holes in the n-type or electrons in the p-type. These carriers and their response to external excitation are basic to the operation of semiconductors. They are injected into the adjacent semiconductor material by the potential across the junction. At equilibrium, a total minority carrier charge, Q_{tot} will be present in the diode at a given value of forward current, I_F. The value of Q_{tot} is dependent upon the magnitude of I_F, the distribution of impurities in the vicinity of the junction, the width of the semiconductor material and the lifetime of the minority carriers (the time required for these carriers to recombine with those of the opposite polarity) in the semiconductor material. To a first approximation, Q_{tot} is directly proportional to the forward current because the lifetime of the minority carriers in the semiconductor material can be controlled in manufacture by the introduction of a controlled amount of gold, which acts as a recombination center for the minority carriers. The other factors are controlled in the design of the semiconductor.

If a forward-biased diode is subjected to a reverse voltage step, a reverse current flows for a short time because of the diode's internal stored charge. A typical waveform for a diode subjected to a large reverse voltage is shown in the figure on page 85. The time required for the diode to recover the blocked condition, and hence its switching speed, depends on the quantity of charge stored, the rate at which the charge is removed by recombination within the diode, and the magnitude of the current flowing in the external circuit. The recovered percentage of Q_{tot} is defined as the stored charge, Q_S. It increases as the reverse current drive is increased, but cannot exceed a certain maximum value determined by the structure of the diode. For a wide-base alloy diode, the stored charge cannot exceed 50% of the total minority carrier charge, while for some types of snap-off diodes the percentage of the total recovered charge can approach 100%.

When an unbiased diode is subjected to a reverse

The author

As an engineering consultant with the General Electric semiconductor products department, T. Peter Sylvan has worked on the development of both signal and tunnel diodes. He has served as chairman of the JEDEC task group which was responsible for developing the standard for diode stored charge measurement.

voltage step, reverse current flows as a result of the charging of the junction barrier capacitance, the stray capacitance and any test jig capacitance that may exist. The capacitance charging current is shown by the lower amplitude curve in the figure at right. To a first approximation, the capacitive charge is independent of the initial forward bias current since the initial and final voltages across the diode are the same.

The stored charge, Q_S, is the recovered minority carrier charge measured under circuit conditions chosen to maximize the recovered charge. The capacitive component of measured charge can be eliminated by taking the difference between the total recovered charge at two different values of forward bias current. This allows the diode switching speed to be characterized under all operating conditions.

Testing for stored charge

Conventionally, the stored charge of a high-speed diode is measured with a sampling oscilloscope and an X-Y recorder. The diode is placed in a suitable test jig. In some cases it may be necessary to reduce the effective source and load impedance of the test jig to satisfy the requirements for a high reverse current drive. The pulse generator used should have a rise time which is as fast as possible. The reverse recovery characteristic of the diode under test is recorded both at zero bias voltage and at the required forward bias current using the sampling oscilloscope, which is also connected to the X-Y recorder.

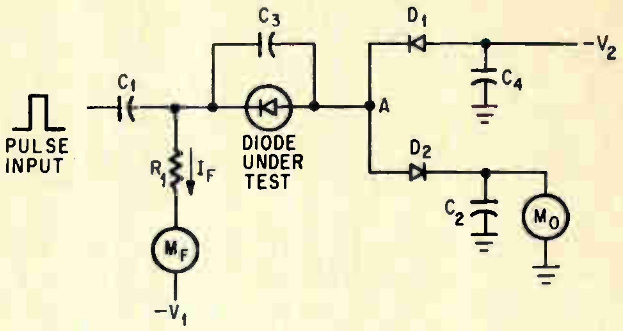
The figure on the right illustrates a typical recording of this type. Current and time calibration marks are made on the same recording. The area under the two curves is then obtained using a planimeter or by counting squares, and the difference between the two areas is taken to obtain Q_S. This corresponds to the unshaded area shown in the figure and is equal to 69 — 8.5 picocoulombs, or 60.5 picocoulombs.

Measuring stored charge directly

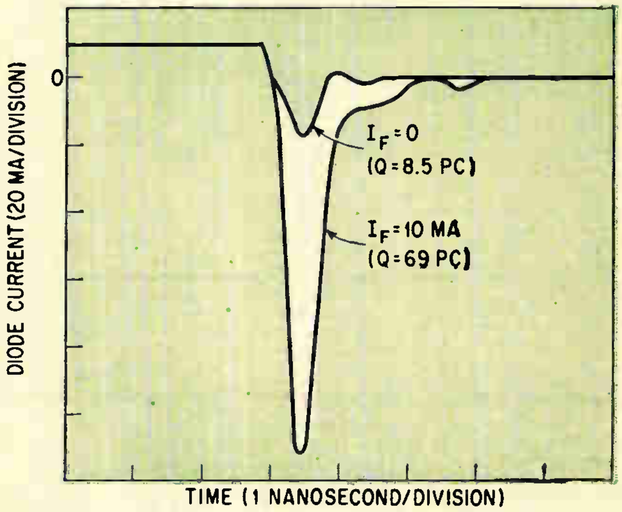
However, it is now possible to measure stored charge directly without elaborate circuits and complex integration techniques. The basic circuit for direct measurement of stored charge is shown in the figure at the right. The diode under test is forward-biased by the current flowing through the bias current meter M_F, R_1, and the diode, D_1. A positive pulse at a known frequency is coupled from the pulse generated through C_1 to the test diode. This pulse reverse-biases the test diode and the stored charge flows through the diode D_2 into integrating capacitor C_2 and the ouput meter M_0. With forward current flowing, output current I_2 is proportional to stored charge, capacitive charge, and leakage current. Algebraically,

$$I_2 = fQ_S + fV_PC'_{avg} + ft_PI_r \qquad (1)$$

where f is the pulse frequency, V_P is the pulse amplitude, C'_{avg} is the average capacitance of the



Test circuit for measuring stored charge in a diode can be constructed using standard components that are readily available to the test engineer.



Waveform of a forward-biased diode subjected to large reverse voltage step. The response of the diode when unbiased, (curve of lower amplitude), is the result of junction barrier, stray and test jig capacitances. To eliminate this capacitive component of stored charge, the area between the response curves of the unbiased and forward-biased diode must be found. This area is representative of the stored change.

test diode and test jig over the voltage range from V_F to $V_F - V_P$. V_F is the forward voltage of the diode under test at a forward current of I_F, t_P is the pulse width, and I_r is the reverse leakage current of the diode under test measured at a reverse voltage equal to V_P. If the voltage across the test diode is set to zero by adjusting V_1, the current I_1 through output meter is proportional to the capacitive charge and the leakage current:

$$I_1 = fV_PC_{avg} + ft_PI_r \qquad (2)$$

where C_{avg} is the average capacitance of the diode under test and test jig over the voltage range from 0 to $-V_P$.

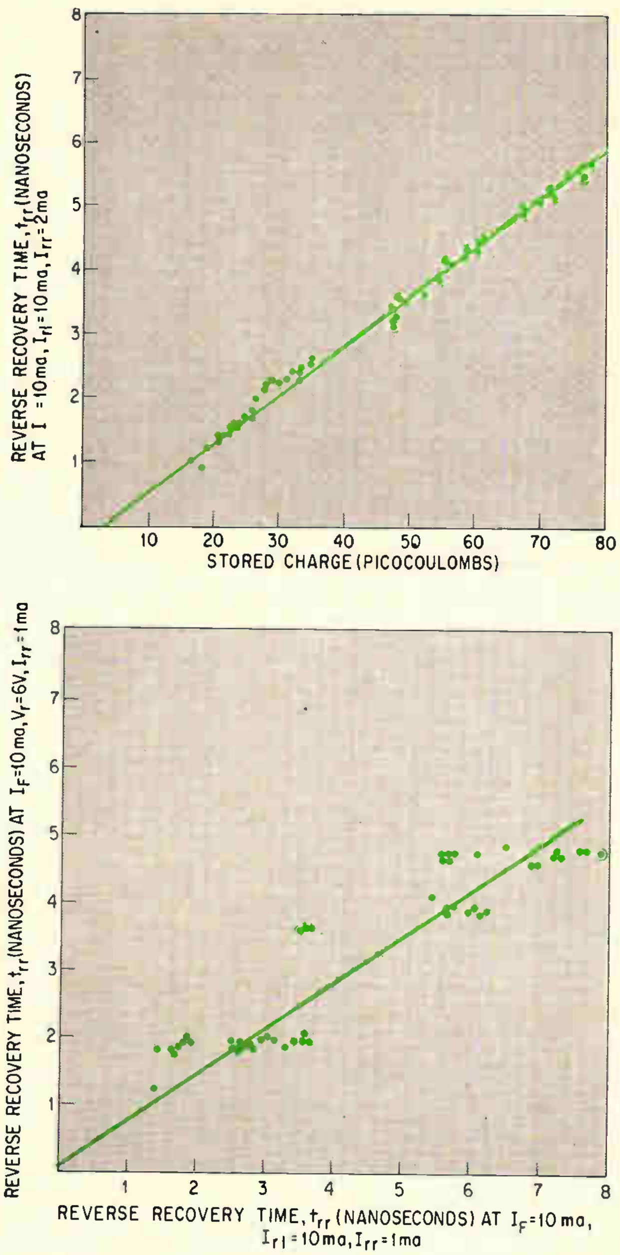
The stored charge is obtained by taking the difference between equation 1 and equation 2 and dividing by the frequency, f. The stored charge is thus determined by the equation

$$Q_S = \frac{I_2 - I_1}{f} \qquad (3)$$

Note that there is a component of capacitive charge contained in the definition of equation 3 since

C'_{avg} and C_{avg} are not equal as a result of the dedependence of the junction barrier capacitance on voltage. Therefore, it is possible for a diode with no stored minority carriers to have a finite measurable stored charge. This compromise in the exact definition of stored charge actually simplifies the measurement of Q_S and relates it more closely to active circuit conditions. The voltage excursions to which diodes are subjected in most switching applications are generally greater than the forward voltage drop of the diode. Hence the stored charge due to minority carriers and the capacitive component are inseparable. But this is really not important to the circuit designer, since he is interested in the total effect.

Since the value of Q_S as defined above depends on the difference between two bias conditions, it reduces the dependence of the measurement on the pulse voltage, the stray capacitance and the reverse leakage current of the diode under test; thus it provides a more significant parameter for characterizing the diode. Effects of leakage current, junction capacitance, pulse amplitude and pulse width can be considered separately by the designer when estimating diode performance in a given circuit.



Correlation between reverse recovery time measurement and stored charge measurement techniques is shown in the top graph. Deviation from the straight line which shows exact correlation is largely due to the reverse recovery time measurement. This is illustrated in the lower graph, a correlation plot of reverse recovery time measurements on the same group of diodes for two test conditions.

Precautions required

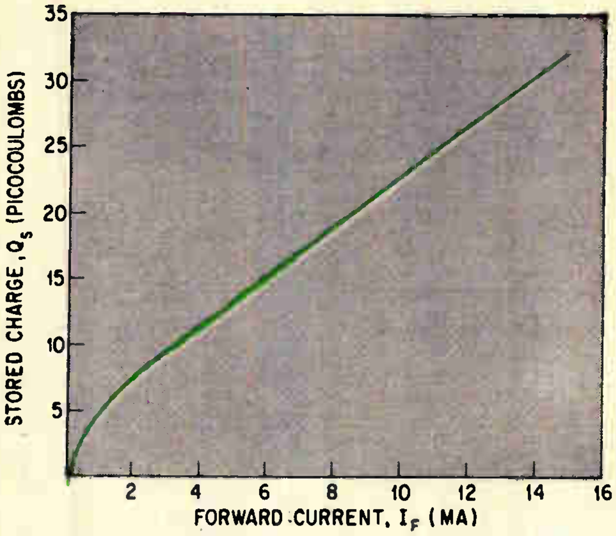
Certain precautions that must be observed when building and using the test circuit shown in the figure on page 85, particularly when making measurements on high speed diodes. The time constant R_1C_1 should be large compared to the pulse width to maintain constant voltage across the test diode during the pulse. Also, the output impedance of the pulse generator and the rise time of the pulse should both be as low as possible to ensure maximum recovery of the available stored charge from the diode under test. A sharp "front corner" is required on the pulse, or the diode under test will be reverse-biased for an appreciable time before the voltage at point A has become sufficiently positive to bias diode D_2 into conduction. This would result in a portion of the available stored charge being lost through recombination within the diode. The top of the pulse should be as flat as possible, with a minimum of overshoot or ringing.

Diode D_1 passes the forward current of the diode under test between pulses. It should have a low reverse leakage current and a much smaller value of stored charge than the test diode. A regulator (avalanche) diode with a low dynamic impedance in the breakdown region and a low capacitance below the breakdown region can be used for D_1 for low stored charge measurements.

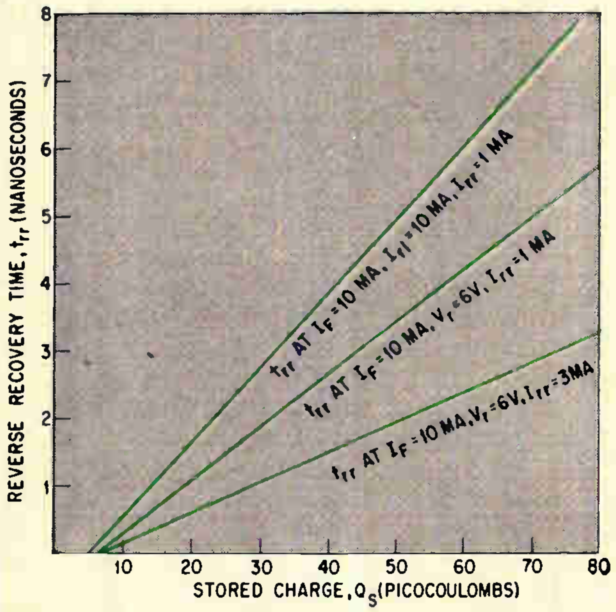
During the pulse, diode D_2 passes the stored charge of the test diode to capacitor C_2 and the meter. The large pulse of current flowing through D_2 makes it necessary that both the turn-on time and the forward voltage drop of D_2 be as small as practical. To prevent the loss of measured charge through D_2 at the end of the pulse, the reverse recovery time of D_2 should be much shorter than the minimum pulse width.

Capacitor C_2 provides a low-impedance path for the stored charge flowing from the diode under test through D_2 during the pulse. Its value should be large enough so that there is no appreciable voltage drop across it during the pulse. In addition, the current meter used should be of a type which has a low input impedance so there is no appreciable voltage drop across it when making a stored charge measurement. Doubling impedance of this meter should not change its reading by more than the required measuring accuracy.

Capacitor C_3, which includes the capacitance of



Stored charge in a silicon planar epitaxial diode has a direct relationship to forward bias current. The nonlinearity in lower current region is due to junction capacitance.



Stored charge versus reverse recovery time for three different sets of test conditions.

the test jig, serves to forward-bias the diode D_2 at the beginning of the pulse so that the full charge of the diode under test can flow through D_2 rather than being partially lost by charging the capacitance between point A and ground; the size of C_3 is adequate when a small current flows through the output meter when the diode under test is removed. However if C_3 is too large, it increases the rise time of the pulse generator.

To ensure recovery of the maximum amount of stored charge from the diode under test, the inductance of all the circuit loops should be kept to a minimum by careful circuit layout and choice of components.

Voltage source V_2 should be adjusted so that constant voltage at point A is maintained under each test condition. If this is not done, the voltage at point A will change with the forward current through diode D_1, owing to its finite resistance. The amount of charge required by the capacitance between point A and ground also changes, resulting in an error in the reading of Q_S. V_2 is normally adjusted so that the voltage at point A is −0.6 volts with respect to ground. Slight changes in the voltage at point A can compensate for minor variations in the parameters of the test circuit to achieve better uniformity in the stored charge measurements on very high speed diodes.

Some further improvements

The measurement method described above is somewhat tedious. It involves taking measurements at two bias conditions, adjusting V_2 to maintain the voltage at point A constant and taking the difference between the two output current readings. To overcome this, an operational amplifier can be used to sense the voltage at point A and adjust the voltage at V_2 to keep the voltage at point A constant. The bias current for the diode under test can be chopped between the two specified values and the output current can be synchronously demodulated to provide a direct indication of Q_S.

The chopper technique also eliminates a zero adjustment on the output meter. Incorporation of these techniques in the basic stored charge test circuit has permitted the measurement of Q_S to be made on a simple "plug in and read" basis.

In most cases, only the diode forward current and the pulse amplitude are needed to establish the stored charge measurement conditions. However, to ensure reproducible measurements on high speed diodes, it is frequently desirable to have additional information: pulse width, pulse generator output impedance, pulse rise time (1% to 50%) the stored charge of D_1, forward recovery time of D_2, high current forward voltage of D_2, and the stored charge of D_2.

Verification

Measurements of the stored charge have been performed on a wide variety of diode types ranging from ultra-fast hot-carrier diodes to very slow silicon rectifier diodes. For high-speed silicon computer diodes measured on independently calibrated stored charge test equipment, the reproducibility of Q_S readings was found to vary by no more than 1% to 5%. This contrasts with a variation of 5% to 40% for reverse recovery time measurements.

Variation of measurement on the same stored charge equipment is generally less than 1%, while the short term stability of readings generally is better than 0.01%. Stored charge measured with the previously described sampling scope technique generally agrees with the direct measurement to within 2%. For example, a measured value of stored charge for the diode shown in the figure on page 85 was 62 picocoulombs, compared with the value of 60.5 picocoulombs obtained by integration of the wave form.

Correlation between stored charge and reverse

Measurement of stored charge in transistors

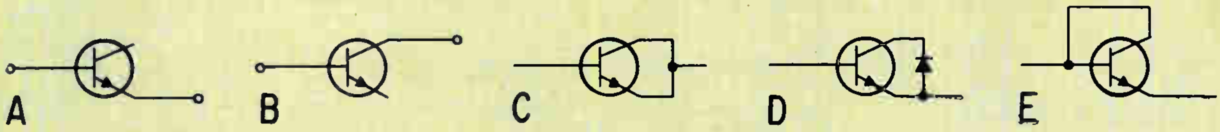
The same test circuit used to measure the stored charge on a diode can also be used to approximate the stored charge parameters of a transistor by use of the diode connections shown in the figure below. The base-emitter diode connection and the base-collector diode connection shown in A and B can be used to determine equivalent minority carrier lifetimes in the emitter and collector junctions of the transistor. These measurements have been found to be useful for transistor design purposes, but are of limited value for transistor characterization and circuit design.

The connections shown in C and D approximate the operation of the transistor in the saturated state and thus give a figure of merit related to the saturation time constant, τ_s. The connection shown in D will give the closer approximation to the saturated switching condition since the bias current flows entirely through the emitter junction while the diode permits the minority carrier stored charge to be withdrawn through both the emitter and collector terminals. Measurements made using the connection shown in (D) have been found to be useful in predicting the trigger thresholds of saturated flip-flops.

The connection of E biases the transistor in the active region at lower current levels and gives a figure of merit which is related to cut-off time, τ_{co} as well as to current gain-bandwidth product, f_T.

Stored charge measurements on medium speed germanium transistors have been made, and good correlation with both τ_s and τ_{co} has been found. Special circuit configurations were used, which permitted the transistor to be biased at any desired current and voltage level. No correction was made for the capacitive component of charge, but transistor switching speeds were low enough so that the resultant error would have been small.

Further work will have to be done to evaluate the usefulness of stored charge measurements for characterizing very fast switching transistors. The objective of such an evaluation should not be merely to determine the correlation between the stored charge parameters and the conventional transistor switching time parameters, but to compare the relative usefulness of the stored charge parameters versus the switching time parameters with respect to the practical requirements of circuit design and production control.

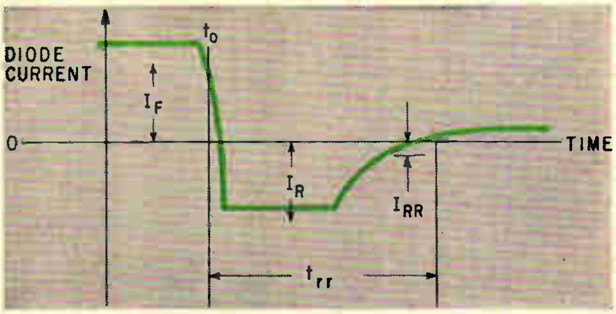


Five diode connections of a transistor allow the measurement of stored charge characteristics to be made and be related to transistor switching parameters.

recovery time t_{rr} is usually within the limits of uncertainty in reading the reverse recovery time (5% to 40%). A correlation plot of Q_S versus t_{rr} for high-speed silicon planar epitaxial diodes is shown in the upper graph on page 86. To illustrate that the deviation from exact correlation is primarily due to the t_{rr} measurement rather than the Q_S measurement, a correlation plot of t_{rr} for two different test condititons for the same group of diodes is shown in the lower graph.

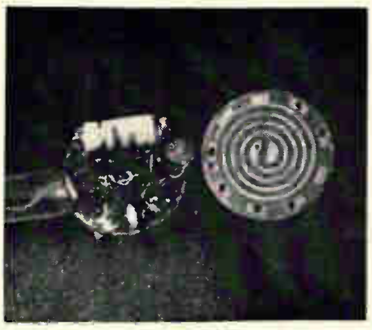
The assumption is frequently made that measurement of t_{rr} at one particular test condition will assure adequate performance of a diode in a switching circuit. The lower graph indicates that large uncertainty in such a relationship exists and that its magnitude is greater for faster diodes. Much of the dispersion in the data of the graph is a direct result of the nature of the reverse recovery time measurement itself. Small discontinuities or mismatches in the diode test fixture may produce large distortions in the diode current waveform in the region of interest. These distortions result in significant differences in the measured values of t_{rr} for the same diode in different jigs, despite care in the construction of the jigs to ensure uniformity. In the measurement of stored charge on the other hand, this problem is avoided since the reverse recovery waveform is integrated and the effects of small distortions in the waveform are therefore minimized.

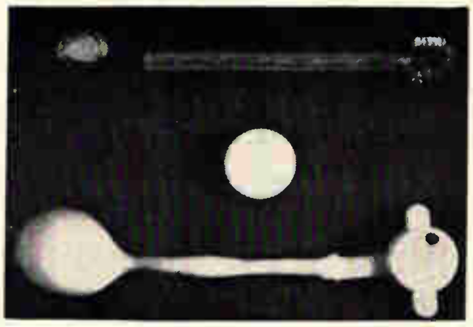
The measurement of stored charge provides the circuit designer with a single, well-defined figure, which is easily obtainable, as an index of a diode's switching speed. The test circuit for stored charge measurement is simple and relatively inexpensive; direct meter readout is possible even with high speed diodes, and the use of sampling scopes is avoided. Errors due to reproducibility of measurement are no longer a problem as with reverse recovery time measurement. In addition, for fast circuits which are charge-sensitive rather than waveform-sensitive, stored charge is a parameter which can be used directly in the analysis of the circuit. It is also possible, with this technique, to make comparative readings of stored charge on ultrafast diodes, which cannot be measured on the faster sampling scopes.



Reverse recovery time, t_{rr} is measured between the turn-off point t_0 to point where reverse recovery current, I_{RR} is 10% of the turn-off current I_R, which is equal in magnitude to I_F, the forward bias current.

K-5 biotelemetry transmitter before encapsulation. Inductor coil is printed circuit at right. Entire unit, when finished, will be 8 mm in diameter by 2 mm thick.





Fully assembled K-5 transmitter is connected to battery at left with twisted lead pair in tube. Lower unit is encapsulated and ready for use. Size is demonstrated by comparison with aspirin tablet in center.

Medical electronics

The special world of biotelemetry design

Unusual solutions were needed to satisfy the unique requirements of implant transmitters. Part 2 of a two-part series

Wen H. Ko and Lloyd E. Slater

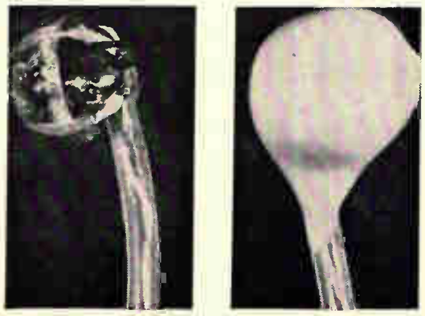
Case Institute of Technology, Cleveland

To design systems that can be implanted in a human body to assist, or even replace, vital organs, an electronics engineer must blend his technology with an understanding of biology and surgery. Because few people have the necessary knowledge, progress has been slow. Still, during the past four years at the Case Institute of Technology, bioengineers—a new name for a new breed—have developed a 0.4-gram implant transmitter, a six-channel multiplex biotelemetering system and a radio-frequency powered implant unit. In cooperation with physicians they have also improved the packaging techniques and surgical methods required for successful long-term implantation.

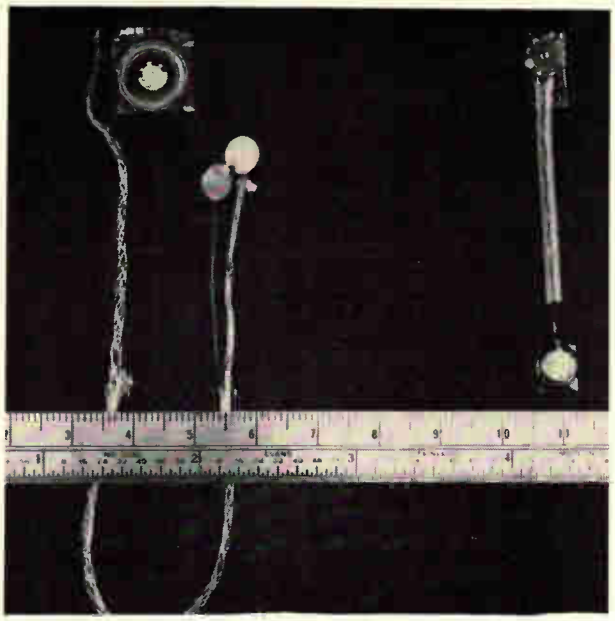
Implant-transmitter design

After considering the magnitude, frequency, and impedance levels of the biophysiological signals of interest, the design of general-purpose implant transmitters must satisfy a unique set of performance requirements.

- Because the body reacts adversely to foreign matter that is either implanted or externally attached, transmitters must be as small and light as possible. Typical acceptable limits are about 1% to 2% of the subject's weight. For the present project they were set at about one gram or less in weight, and one cubic centimeter in volume.
- Most physiological information either is directly sensed in the form of bioelectric potentials, or converted into electrical signals by a transducer. Either method results in low-level signals in an environment of high-level noise. This creates the need for transmitters with a dynamic range of 10^3, maximum to minimum signal ratio, and low internal noise. In addition, they must have the proper frequency response to cover the spectrum of the generated information—usually from 0.01 cycles per second to several kilocycles per second.
- For a long useful life, the transmitter must be



Power detector package before and after encapsulation.



Implant biotransmitter, right, represents three years of development which started with the surface-mounted unit, model K-1, left. The K-1 is 0.7 cc in volume and weighs 1.7 gm. The latest K-5 unit is 0.1 cc in volume and weighs 0.44 gm.

designed for minimum power consumption. At Case, the target was milliwatts or less. One of the tasks of the research team was to evaluate or develop new methods of powering implanted transmitters so that the restrictions of battery operation could be eliminated.

- Reliability is essential. The transmitter must be relatively free from variations in frequency caused by power supply fluctuations while operating as an implant, or when attached to the surface of the body. And individual transmitters must not interfere with other units operating nearby.

Frequency modulation

To meet these requirements, the designers at Case selected two f-m oscillator-modulator circuits for further development. For low power consumption and low noise, tunnel diodes were chosen as the active oscillator element.

Five models of f-m transmitters have been developed at Case that use two types of frequency modulation. The models are designated K-1 through K-5. In the K-1 to K-3 units, modulation is achieved by varying the bias on the tunnel diode oscillator. In the K-4 and K-5 models, the oscillator tank circuit resonance frequency is varied by controlling the capacitance of a varactor diode.

A typical current-voltage characteristic of a tunnel diode is shown on page 91. In segment bc, the current decreases as voltage increases, resulting in a negative resistance. When biased to operate in this negative region, the tunnel diode may be used as an oscillator as in the circuit shown at the top of page 91. For sustained oscillation the d-c source resistance, R_b, must be smaller than the value of diode negative resistance, $-R_d$. The frequency of oscillation is determined by the resonant circuit formed by C′L′R′ and the tunnel diode, where R′ represents the total resistance of the oscillator circuit including that caused by radio-frequency radiation.

In the r-f equivalent circuit of the oscillator shown in the diagram on the next page, C is the parallel combination of C′ and the capacitance of the tunnel diode, C_d, at the operating point. Since the values of R_d and C_d are a function of the diode bias voltage, the frequency varies with bias. The graph at the upper right of the next page shows the correlation between frequency and bias and between frequency deviation and bias for a typical circuit. In the K-1 unit, a frequency deviation, (df/dv), from 50 to 500 kc/mv at a carrier frequency of 100 megacycles was observed at the proper bias voltage.

If the oscillator output is modulated by varying the bias of a tunnel diode operating in a region of constant deviation, a large frequency-modulation index may be obtained. As the circuit diagrams on page 92 indicate, the K-1 and K-2 transmitters use this modulation technique. A K-3 model, not shown, is the K-1 circuit built with thin film components. The measured transmitter-receiver noise level is about 1 μv in these circuits. However, they present design difficulties because precision components are required, the power supply voltage must be regulated within a few microvolts, the input impedance is low and the gain and frequency exhibit serious instability with temperature variations.

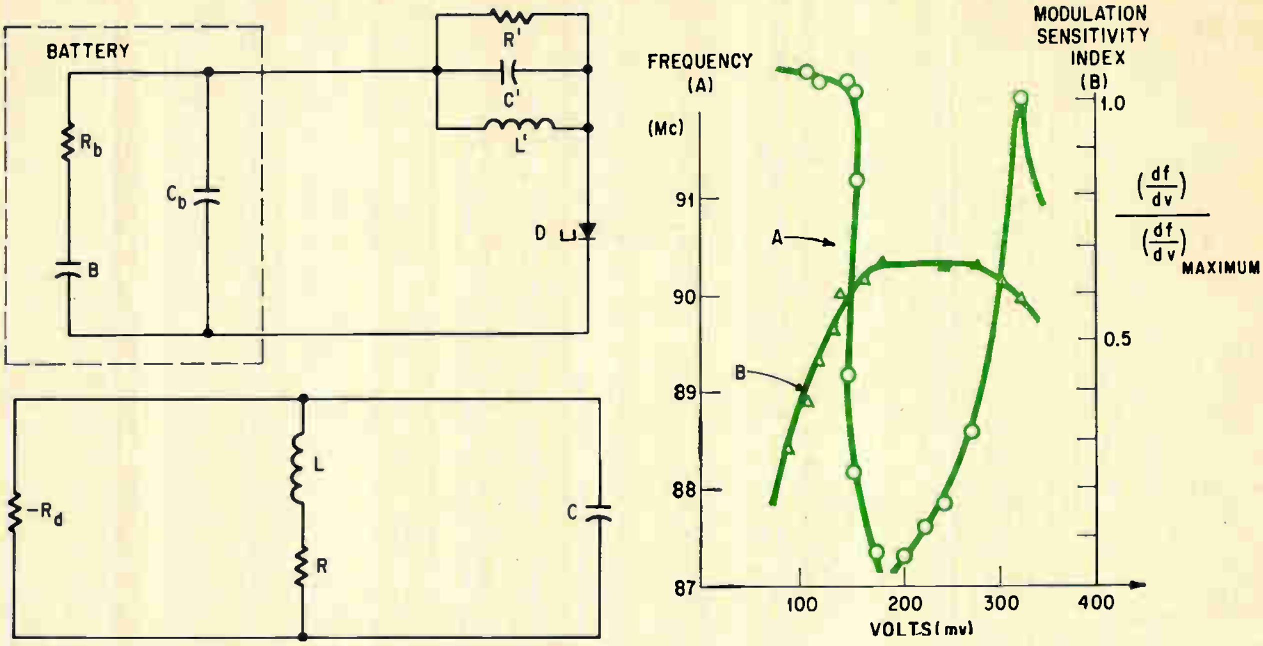
Solving some problems

The K-4 and K-5 models were designed to overcome most of the earlier difficulties. An emitter follower in the K-4 transmitter, and a backward diode in the K-5 bias the tunnel diode oscillator at a point where its frequency is not sensitive to changes in the d-c bias voltage. The a-c equivalent circuit of the K-5 oscillator can be reduced to that shown in the r-f equivalent circuit diagram on the facing page. The operating frequency is determined by coil L, total loss resistance R, and the combined capacitance C, which includes the capacitances of the tunnel diode and the modulating diode D_1. The input signal varies the bias of D_1 thus modulating the oscillator frequency.

In the K-5 circuit, the backward diode functions as a temperature-stable voltage regulator and the frequency stability is greatly improved. The input impedance is raised to above 1 megohm by the modulating diode. However, the modulation sensitivity (df/dv) is greatly reduced. Sensitivity may be improved considerably by varactor diodes with an extremely high capacitance-to-voltage ratio.

A comparison of the design criteria and characteristics of the five transmitter models is tabulated in the table on page 94.

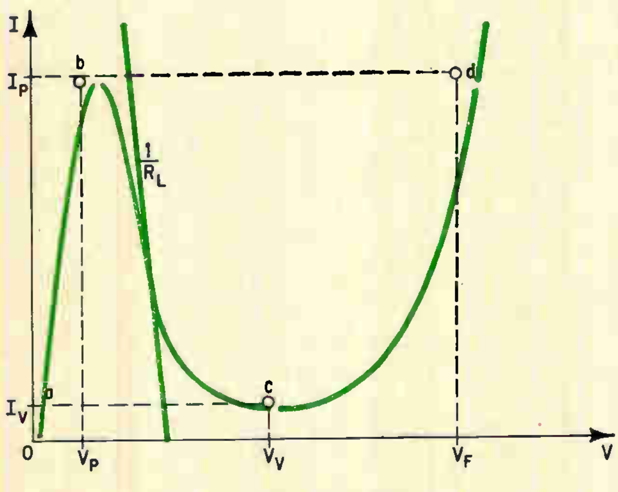
The most recent design, the K-5 unit, employs many of the techniques that evolved from the four earlier designs. The tunnel diode used in the K-5 unit is formed from germanium doped with 3.35 ×



Tunnel diode oscillator, circuit at top, and its radio-frequency equivalent circuit. At the right, frequency and modulation-sensitivity index characteristics of a tunnel diode are plotted against voltage. For large modulation index, operating point is selected to lie in region of constant modulation sensitivity.

10^{19} atoms per cubic centimeter of arsenic. Dots of 99% indium, 1% gallium, are alloyed to the crystal by the strip heater process. The tunnel diode has a peak current of 1 milliampere, peak-to-valley ratio of 8 to 10 and a capacitance, C_0, at the valley point, of about 0.5 picofarad. It is packaged in an epoxy pellet about 1.5 millimeter in diameter.

The backward diode is formed from either the same type germanium crystal used for the tunnel diode or from 0.001 ohm-centimeter germanium crystal, and 2% gallium—98% indium dots. In the fabrication process, both the temperature and heating cycles are controlled carefully to produce a



Tunnel diode current-voltage characteristic. Negative resistance exhibited over segment bc allows device to function as oscillator. Load line with slope $1/R_L$ is for astable operation.

large-area narrow junction. The junction capacitance at zero bias is about 3,000 picofarads. The bias current is about 0.8 to 1.0 milliamperes and the voltage between 0.16 to 0.22 volts. Its temperature coefficient is approximately 0.05 millivolts per degree centigrade. The dynamic resistance is nominally 20 to 40 ohms. The backward diode, D_3, functions as a temperature stable, low-voltage reference, and provides the r-f bypass capacitance, C_p.

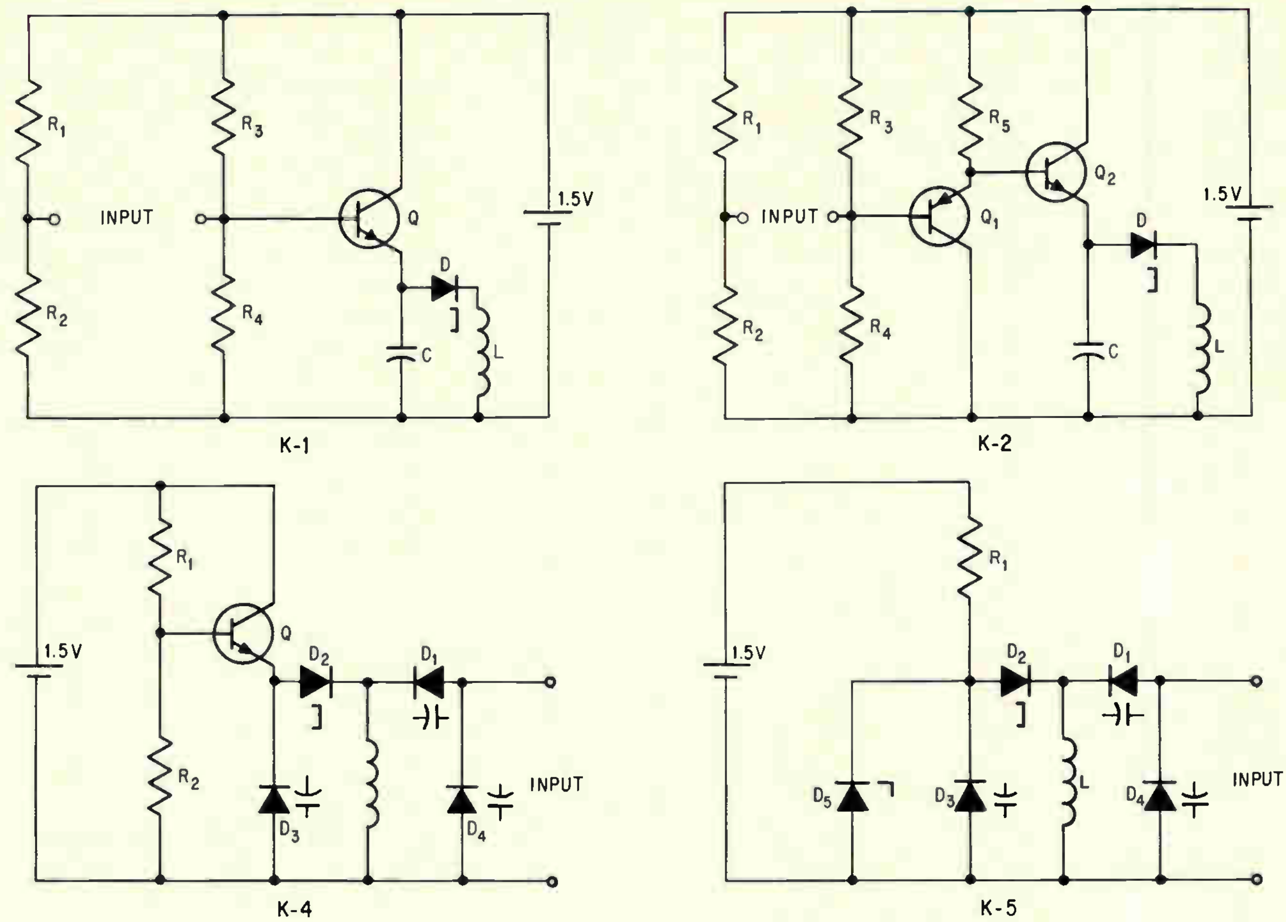
The modulating diode in the K-5 unit can be either an ordinary varactor diode or an abrupt-junction varactor diode with appropriate capacitance. The capacitance sensitivity of these varactor diodes ($\Delta C/\Delta v$) is small. To increase sensitivity, hyper-abrupt junction varactors are used. It was also found that the capacitance of certain alloyed and diffused junction diodes is more sensitive to bias variations. The transition capacitance of a varactor can be represented as:

$$C_d = \frac{C_{do}}{(V_D - V_a)\ m}$$

where V_D is the diffusion potential of the p-n junction in the varactor, V_a is the applied voltage, C_{do} is a constant that depends upon the material for a particular varactor and m is a constant which is determined by the type of varactor junction. The usual values for m are ⅓ for graded junctions, ½ for abrupt junctions, and greater than ½ for hyper-abrupt junctions.

Some of the high sensitivity diodes tested have an equivalent m value of 0.7 to 3.0, measured at 200 megacycles per second.

The bypass capacitance, D_4, in the K-5 transmitter, is an ordinary silicon or germanium large-



Tunnel diode oscillator circuits used in biotelemetry transmitters designed at Case Institute of Technology. In the K-1 and K-2 models, the bias of the tunnel diode is varied to change the oscillating frequency. The K-4 and K-5 units use a varactor-diode to vary the tuned-tank circuit resonance.

area varactor diode with zero-bias capacitance of the order of 200 to 1,000 picofarads. The inductance, L, is a gold-plated copper spiral, 6 millimeters in diameter, printed on a 1/32-inch fiberglass board. The resistor can be either a diffused semiconductor type or a conventional 1/10- or 1/20-watt resistor.

The multiple-chip integrated circuit technique was tried. However, it added nothing to the design of the K-5 but additional cost. High-density packaging is used for the K-5 units. All components are individually protected and tested before being assembled on the reverse side of the printed coil, L, as illustrated in the photograph on page 89.

Guidelines for the K-5

In the final K-5 design, sensitivity, frequency stability, input impedance and dynamic range were considered in that order. These were the guidelines:

- The frequency of the transmitter is limited to less than 300 Mc because the body attenuation increases rapidly with frequency beyond 300 Mc. The lower limit of the frequency, typically 100 to 200 Mc is set by the size and weight of the coil, L.
- The m value of the varactor diode is determined by availability, frequency stability, and specified noise limits. Typical range of m is from 0.7 to 3.0 at the operating frequency.
- The choice of the varactor entails a compromise between sensitivity and impedance.
- Unwanted capacitances are kept to a minimum by packaging layout and careful selection of components.
- Values of C_d, L/C_d ratio and R/R_d ratio must be as small as possible

The calculated performance of the transmitter design is tabulated on page 96, and a summary of the laboratory test results of both the K-1 and K-5 units is tabulated on page 93. The results show that the K-5 transmitter can be used in most biotelemetry applications where frequency stability is a more important consideration than sensitivity. Otherwise the K-1 circuit is recommended.

The assembled transmitter is spray-coated with Krylon to seal all the components. Then it is embedded in a hard epoxy for rigidity. Sometimes a ferritic powder may be mixed with the epoxy, resulting in a magnetic core that can be used to adjust the carrier frequency. In recent units, paraffin was used instead of Krylon as the first coat. Epoxy is again used for the second coat. Finally the transmitter is potted in silicone rubber (Dow Corning Medical Silastic 382), a material that is compatible with body tissues. Platinum electrodes are connected to the input of the transmitter and used to sense the changes in the biological potential. Extensions, known as ears, allow the transmitter to be sutured to the body of the subject.

The power supply is packaged in a separate unit and is protected by paraffin and covered with 1 millimeter of Silastic. Leads from the transmitter are coiled inside a Silastic tube (Dow Corning 372) for connection to the battery package. After potting, the transmitter is 1.1 centimeter in diameter and 5 millimeters thick, and weighs about 0.05 ounce. The assembled unit, before and after potting, is shown in the picture on page 89.

Rabbits and mice

The implant transmitters were evaluated on rabbits. The units were implanted in the animals' right rear quadriceps muscle. The basic problems encountered were medical rather than electronic. They included a need for developing general surgical techniques for rabbits, obtaining a low-temperature sterilization procedure, fixing the unit securely in position, obtaining optimum package shape to control connective tissue growth and determining the best electrode configuration.

The partial solution of these problems was reported in detail on Aug. 25, 1964 by Dr. R. Grotz and others at the 42nd Congress of Physical Medicine and Rehabilitation in Chicago.

Thirty implant operations were made to permit transmission of electromyograms (EMC) or the bioelectric action potentials of muscles of unrestrained rabbits. Continuous transmission from each biotelemetry unit was obtained for a maximum period of 10 days, limited only by the battery life. Implanted transmitters removed from the body after four months were found in good operating condition with only the battery requiring replacement.

The illustrations on page 94 show the EMG signal from an unrestrained rabbit and the EKG of a mouse—both obtained with an implanted K-5 telemetering package. Signals of this quality could not be recorded from a subject in a natural state without the radio transmitter.

Eliminating the battery

A method of providing power to the transmitter by radio induction at 1 megacycle is being studied. A 30 x 24 x 14 inches cage has been built with coils wound around its outside surface. The coils are energized by a 150-watt power oscillator. Designed to be implanted in subjects kept in the cage is a detector unit having three mutually perpendicular coils and rectifiers. The over-all detection package is a ⅜-inch diameter sphere also containing the necessary filtering components. The circuit diagram of the detector is shown on page 96. A picture of the prototype design is shown on page 89. Laboratory tests have demonstrated that the detector coils, though indiscriminately oriented within the cage, are capable of supplying 1.5 volts at 1.5 milliamperes when the power oscillator output is approximately 100 watts.

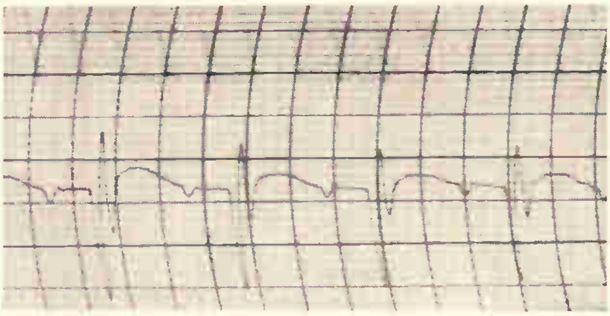
Six implants of radio-powered K-5 units were made. Four units placed in rats successfully transmitted heart rate and respiration data simultaneously. Two other units were used to transmit electromyograms from rabbits. The data was transmitted continuously for periods up to two and a half months, interrupted only by the moving of equipment. It is believed that the measurements could have been made over the animals' entire lifetime. The transmitted signals compared favorably in quality with those from the battery-powered unit. This was attributed to the fact that the power oscillator output had small harmonic content and the power supply was regulated and filtered to have less than 0.01% ripple content.

Six-channel multiplex system

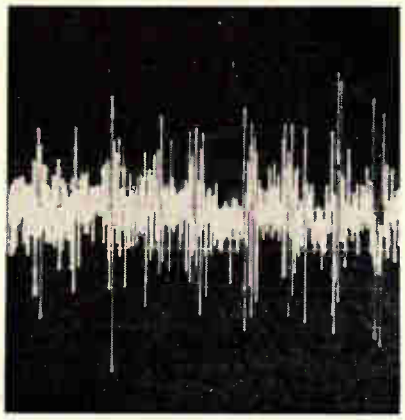
A complete six-channel multiplex f-m/f-m bio-

Laboratory test results of K-1 and K-5 transmitters

Characteristic	K-1	K-5
Size without battery	1.3 cm x 1.3 cm x 0.4 cm	0.8 cm dia. x 0.2 cm
Weight without battery	1.7 grams	0.44 grams
Power consumption	1.3 volts at 1.2 milliamperes	0.2 volts at 1.2 milliamperes
Frequency (may be extended from 50 to 500 megacycles)	80–100 megacycles	100–250 megacvcles
System gain $\left(\frac{\text{discriminator output}}{\text{signal intput}}\right)$	8000	1000 to 4500
System noise (1 kc band in shielded room)	0.5 microvolts (5 kilohms input)	1.5 to 3.5 microvolts (10 kilohms input)
Input sensitivity (6 decibles signal-to-noise)	1.0 microvolt	3 to 7.0 microvolts (rms)
Dynamic range	2 x 10^3	10^3 (limited by receiver)
Frequency response	0.01 cps–20 kc	0.01 cps–20 kc (limited by receiver)
Input impedance	5 to 8 x 10^3 ohms	300 x 10^3 ohms or higher
Transmission range	5 microvolts at 12 feet (with 4 inches lead)	5 microvolts at 4 to 8 feet (without leads) 20 ft with 14-db gain antenna
Carrier frequency temperature stability	poor	less than 0.05% per degree centigrade



Electrocardiogram obtained from a mouse at a distance of 30 feet with the K-5 transmitter. Antenna loop is visible on back of mouse.



Electromyogram of unrestrained rabbit shows quality of transmitted information available with biotelemetry units.

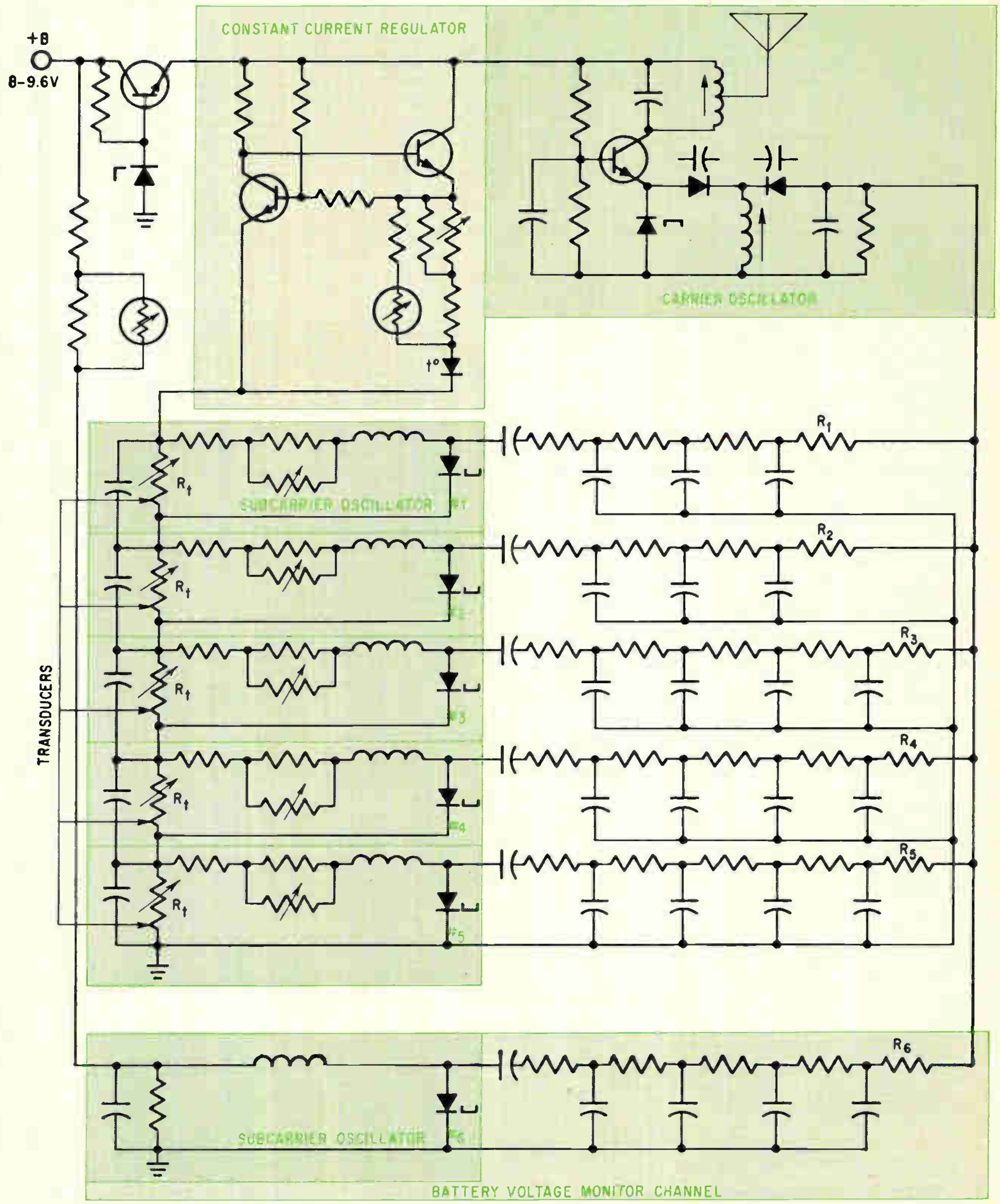
telemetering system was designed and built in order to monitor several physiological signals simultaneously. The circuit digram of the transmitting unit is on page 95. Designed for external surface mounting, the system has been used on a paralyzed human subject to monitor two surface temperatures, and one internal temperature, respiration rate, patient orientation, and muscle spasm. Data was recorded continuously over a period of 40 hours, with the patient at a distance of 50 to 100 feet from the recorder. The characteristics of the transmitting and receiving systems are shown in the table on page 96.

As the circuit diagram of the transmitter shows, tunnel diode voltage-controlled oscillators with R-C filters are used as the subcarrier generators. The bias voltages of the six subcarrier oscillators are regulated by a constant current regulator. Input transducers are variable resistances in the constant current bias circuits. The transducer's resistance change causes a variation in the subcarrier frequency which in turn modulates the frequency of the carrier oscillator in a mixer circuit. The carrier frequency is between 110 and 130 Mc.

A modified commercial f-m tuner is used as the receiver. The output of the discriminator is separated into the desired channels by a bandpass filter. Demodulation of the subcarrier is accomplished by pulse-averaging discriminators. The sine-wave output of the bandpass filter is amplified, clipped and differentiated to generate pulses whose zero-crossings trigger a clamped monostable multivibrator to produce an output pulse of fixed ampli-

Characteristics of five f-m transmitters, K-1 through K-5.

Model	Design emphasis	Characteristics
K-1	Low noise, high sensitivity	0.5 μv system noise, 6,000 ohms input impedance Size: 1.3 x 1.3 x 0.4 cm³
K-2	High input impedance (use complementary compound transistors)	5 μv system noise, 200 kilohms input impedance Size: 1.2 cm dia x 2.5 cm long
K-3	Small volume, light weight	Thin-film version of K-1 Size: 1 cm² x 0.1 cm
K-4	Small volume, light weight	Multiple-chip integrated circuit on ceramic wafer Size: 1.3 cm dia. x 0.2 cm
K-5	High impedance, good stability, simple circuitry	3.5 μv system noise, 300,000 ohms to megohms input impedance, good temperature stability, uses special components Size: 8 mm dia., 2 mm thick



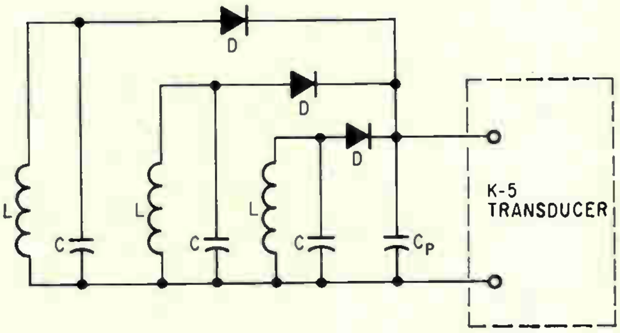
Six-channel multiplex f-m/fm biotelemetry transmitter uses resistive transducers to measure physiological phenomena. These transducers are powered in series by a constant current source and, as a result, draw the same amount of power from the battery supply, minimizing drain. A battery voltage monitor channel is also used so observer can check system without shutting it down. Six subcarriers are linearly mixed and fed to the tunnel diode r-f carrier oscillator. Resistances, R_1 through R_6, are carefully selected to prevent interchannel interference. RC filters were used to eliminate harmonics in the tunnel diode subcarrier oscillators. Size, weight and power considerations prevented use of more efficient active or cascaded notch filters

Characteristics of six-channel biomonitoring system

Transmitting system	
Transducer impedance	200 ohms typical
Input sensitivity	±10 ohms typical for a ±7.5% subcarrier frequency deviation
Linearity of resistance-modulated subcarriers	Less than ±2.0%
Time drift (after ½ hour warm up)	Less than 0.5% of demodulator bandwidth for 24 hours at 25°C
Thermal stability	From 20°C to 40°C, subcarrie center frequency is stable within ±1.0% of demodulator bandwidth; carrier frequency is stable within ±0.2%
Stability with supply voltage	For a 1.0 volt drop in battery potential, subcarrier frequency is stable within ±0.2% of demodulator bandwidth
Receiving system	
Output	±100 mv for ±7.5% deviation
Output noise	Less than 1 mv
Linearity of subcarrier discriminators	Less than ±1.0%
Time drift	Center frequency drift for 24 hours less than 0.25% of demodulator bandwidth
Thermal stability	Center frequency stable to 0.5% of demodulator bandwidth from 20°C to 40°C
Stability with supply voltage	Fluctuations in line voltage between 105 and 130 volts cause center frequency variation of less than ±0.5% of demodulator bandwidth

Calculated performance of K-1 and K-5 transmitters

	K-5 transmitter at 190 Mc.			K-1 transmitter at 100 Mc
	Abrupt junction diode	Hyper-abrupt junction diode		
m value of diode	0.5	1	2	—
Sensitivity = df/dv (kilocycles per millivolt)	28	56	112	150-300
Minimum signal (microvolts) (6 decibles signal-to-noise-ratio)	18	9	4.5	2
R_{in} (ohms)	10^6–10^8	10^6	3×10^5	5×10^3
Max. signal (millivolts)	20	10	5	1



Power detector circuit used for externally powering the K-5 transmitter.

tude and duration. These pulses are then integrated to produce a d-c signal that varies proportionally with the instantaneous subcarrier frequency. Temperature compensation maintains constant pulse amplitude and width over the operating temperature range.

For the future

Ahead of the bioengineers at the Case Institute of Technology are many more problems demanding solution. They include:

▪ Miniaturization. The reduction in size of current designs to an implant unit weighing 0.3 grams or less and 0.1 cubic centimeters in volume. Parallel reduction in size of the multiplex telemetering system to permit innocuous body mounting.

▪ Energy sources. Further refinement of external r-f powering systems and the investigation of body fluids as an energy source, employing the fuel cell principle.

▪ Transducers. New miniaturized transducers and sensors must be developed compatible in size with associated transmitting equipment; the greatest potential is seen in exploiting semiconductor effects associated with various physical and chemical variables.

▪ Implant techniques. Further work is planned in placing biotelemetering equipment in body areas and on specific internal organs. A near-future goal is the study of implants in humans.

▪ Body reactions. Work is planned in the study of r-f wave propagation within the body, surface reactions, and long-term effects of implants and surface materials in various areas of the body.

▪ Stimulus systems. The design of microminiature stimulators based on new microelectronic devices is currently in progress. These units receive an r-f signal, shape it, and deliver a stimulus to the organ or tissue under study. An additional unit in the implant will sense the body response to the stimulus and relay the information to the stimulus controller.

An electronic variable attenuator for use with uhf receivers

Low insertion loss and wide dynamic range make this stripline-diode combination effective in preventing overload at frequencies from 20 to 500 Mc

By M.F. Brown and Henri T. Pichal *
Electronic Communications, Inc., St. Petersburg, Fla.

As solid state equipment becomes increasingly prevalent in communications, automatic gain control (agc) becomes more and more difficult, especially where a transistor is used to amplify radio frequencies above 200 megacycles per second. With conventional agc techniques applied to transistors, it is impossible to handle satisfactorily the wide range of input signals to which receivers are subject, particularly in a military environment.

Without automatic gain control at the radio-frequency or antenna-amplifier stages, strong signals can cause severe overloading of receivers in the first mixer or in subsequent stages, resulting in intermodulation among the various signals present. In frequency modulation and multiplex transmission, this effect is disastrous because modulation in each subcarrier channel appears in every other channel.

Although agc methods are available and in use, the advent of high-frequency transistors designed for operation as r-f amplifiers or mixers in the range from 100 to 500 Mc has introduced the problem of restricted dynamic range. No satisfactory method has yet been found to provide a true gain control, automatic or otherwise, within a transistor operating above 100 Mc, without impairment of the minimum noise figure, limited attenuation range or significant distortion. Especially in multiplex applications, intermodulation problems are so severe that any attempt to control a transistor's gain reduces the receiver's dynamic range rather than enhancing it.

The authors

M.F. Brown is responsible for design and development of military communications equipment at Electronic Communications, Inc., and has done other engineering work on solid state uhf receivers and amplifiers.

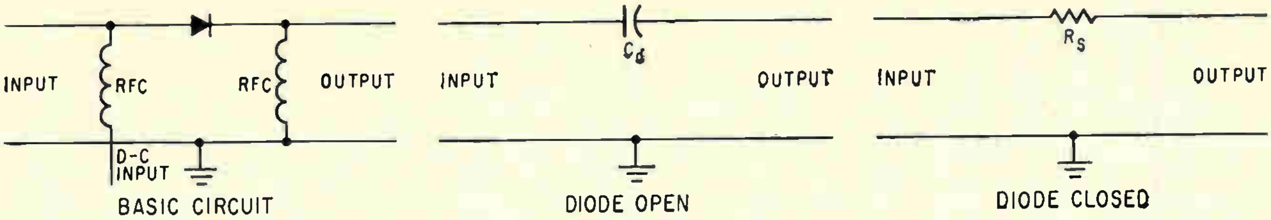
Henri T. Pichal received much of his engineering education in Great Britain and has been engaged in developing electron-tubes and designing solid state communications equipment.

* Now president of the Space Electronics & Engineering Corp., St. Petersburg, Fla.

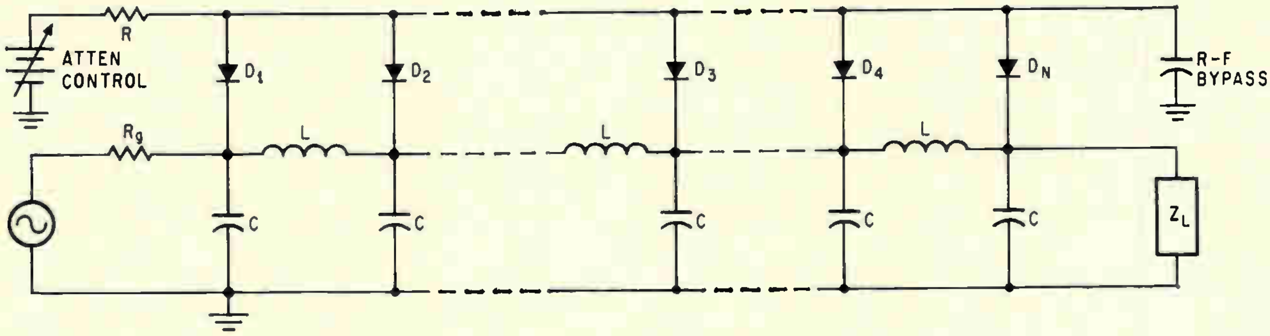
Electronic variable attenuator

An electronic variable attenuator has been developed to operate at 225 to 400 Mc between the antenna and the r-f amplifier of a receiver. It offers an insertion loss of less than one decibel, frequency coverage from 500 down to 20 megacycles, simple design using low-cost conventional diodes, no loss of signal when control voltage fails, and a dynamic range greater than 70 decibels. The attenuator is also fail-safe; it will not burn out in the presence of high-power transmitters or radars. And its physical geometry is flexible, allowing it to be placed directly into a coaxial antenna feeder.

The use of diodes for attenuation is not new, but early attempts to develop an electronically controlled attenuator or switch were confined to using a diode in series with the r-f signal. To ensure a minimum insertion loss with that approach, a relatively large forward direct current was required to be conducted through the diode. However, every



Series diode switch that has been replaced by shunt attenuator depends for its isolation primarily on C_d, while its insertion loss is mainly a function of R_s.



Circuit diagram of stripline attenuator. The line's distributed contents are represented by C and L.

diode having a large forward current capacity exhibits a large capacitance across its terminals when reverse bias is applied. Hence, the series-type diode attenuator, shown in the drawing above, cannot provide both small forward insertion loss and large reverse insertion loss. The r-f leakage across the diode's capacitance in the reverse-biased condition limits the attenuation range of a series diode at high frequencies.

Special diodes such as the p-i-n type, with an intrinsic layer between the p and n layers, have been developed to provide better performance in series attenuators and switch applications, but in every case a compromise must be accepted. For example, there is danger of burnout in the presence of a large r-f signal. Furthermore, where unwanted capacitance has been tuned out by inductive reactances, the operational frequency range is severely reduced.

These problems exist with all series-type electronic switches and attenuators employing diodes. Such devices are also expensive, costing $150 to $850. The large direct current required to render low forward resistance also poses the risk of failure in equipment or system, with a loss of d-c supply.

Shunt-diode system

With the electronic variable attenuator for which details are outlined, the r-f amplifier operates continuously at class A, providing the receiver with optimum noise figure when the attenuator is in the off condition. Minimum distortion is ensured when the attenuation is in the maximum loss state.

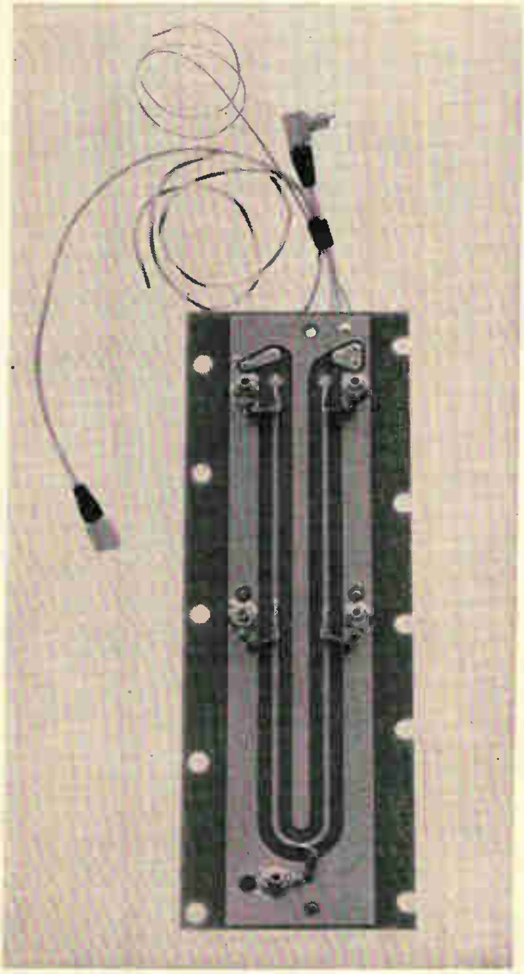
The attenuator shown above in schematic form is basically a microstrip line operating in the TEM mode, with five diodes placed 2.172 inches apart—one-eighth of a wavelength at 312 Mc—and each grounded to a feedthrough capacitor. The capacitor makes the diode ground plane and the actual ground plane on the back side common at radio frequencies as shown in the photographs. This arrangement also allows the d-c source to be applied across the two ground planes that are isolated for direct current.

When no voltage is applied, the diodes appear as capacitors having a typical value of 1.5 picofarads. In this mode, the composite characteristic impedance of the line appears as 50 ohms, in which case the insertion loss is a minimum. The curves show the insertion loss at the frequency extremes of the attenuator, with three types of diodes for different values of forward direct current.

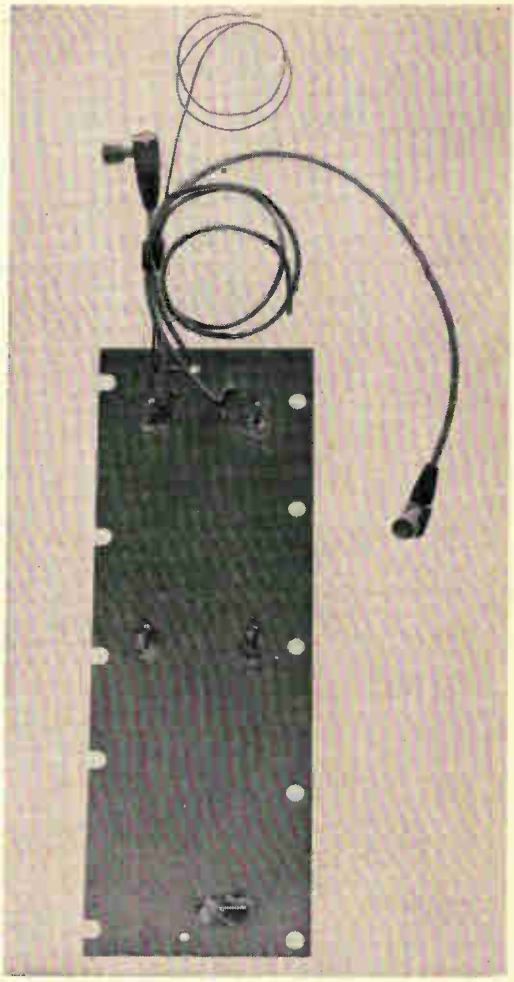
As the forward direct current is increased, the r-f attenuation also increases. Basically, the attenuator is a coaxial or microstrip line in which (at zero direct current) the distributed capacitance is augmented by discrete lumped capacitance (the diodes) placed at distinct intervals along the line. This results in a total distributed capacitance per unit length, C_T. Attenuation occurs when forward bias is applied to the diodes, and the distributed capacitance C_T progressively gives way to the diodes' forward conductance.

Aligning the diodes

The geometrical layout shown in the photographs is only one of many types tried, and does not result in maximum attenuation. Maximum attenuation is obtained for a given number of diodes when the input and output are separated as far as possible, as in a straight piece of microstrip. For example, attenuation in excess of 70 decibels was obtained with a straight line employing only five diodes. Because of ground dislocations, slightly less atten-



Experimental stripline, with five diodes spaced one-eighth of a wavelength apart, can also be constructed in a coaxial line.



Underside of stripline is a metal surface to which one end of each diode is connected via feedthrough capacitor.

uation is obtained with geometries other than the straight line. By increasing the length of the line and adding more diodes, the attenuation can be increased further, but only with an increase in the insertion loss at zero bias. The best geometrical layout depends upon the amount of attenuation needed, space requirements and the maximum tolerable insertion loss.

In selecting appropriate diodes, four parameters must be considered: capacitance at zero bias, forward conduction, power-handling capacity and breakdown voltage.

Low-capacitance diodes are desirable for two reasons. If the diode's capacitance is too large, the width of the microstrip line must be excessively small, and small widths are difficult to fabricate accurately. Also, because the absolute capacitance change from diode to diode will be greater for higher-capacitance diodes, there will be a lack of uniformity in attenuator characteristics, especially in zero-bias insertion loss.

Power-handling capacity and breakdown voltage are generally important only when the power level exceeds one watt. In this condition, diodes with breakdown voltages above 40 volts will suffice.

The microstrip line

After the diode type has been selected, the dimensions of the microstrip line still must be determined. To keep the approach practical, only those formulas and calculations are given that are necessary for attenuator design and construction.

The characteristic impedance of a microstrip line is given by

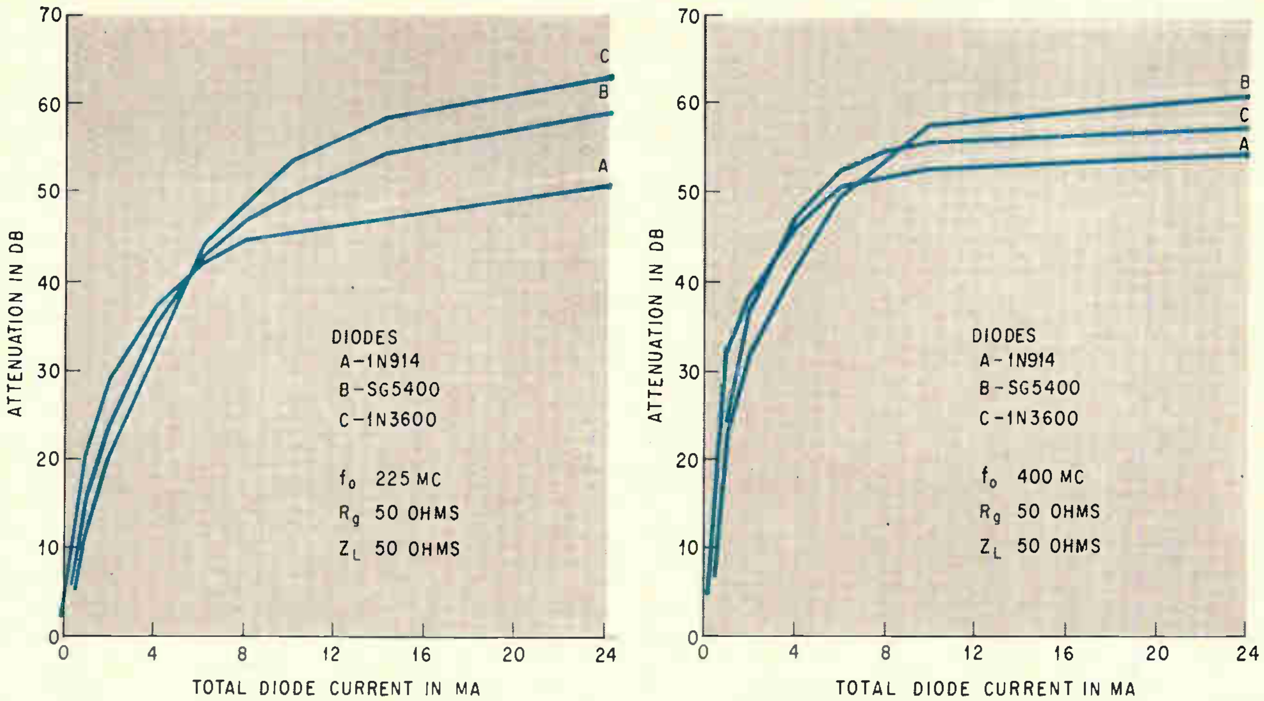
$$Z_o = \frac{\sqrt{(\mu\epsilon)^{1/2}}}{3C_T 10^8} \text{ ohms,}$$

where μ = magnetic permeability (equal to one for air and most dielectrics), ϵ = dielectric constant (equal to one for air) and C_T = total capacitance per unit length in picofarads per meter.

For all of the following calculations, it is assumed that $\mu = 1$ and that glass fiber-base microstrip is used ($\epsilon = 4.9$). The equation reduces to $Z_o = 0.736 \times 10^{-8}/C_T$ ohms. For any given Z_o, the required capacitance C_T can be found.

$$C_T = 0.736 \times 10^{-8}/Z_o \; pf/\text{meter}$$

When $Z_o = 50$ ohms, $C_T = 147.0$ pf/meter or 3.73 pf/in. This capacitance is made up of three parts in parallel: $C_T = C_f + C_{pp} + C_{dd}$, where C_f = fringing capacitance, C_{pp} = parallel plate capacitance and C_{dd} = equivalent diode distributed capacitance.



Variable attenuator versus total diode current for an operating frequency of 225 Mc (left) shows greater differences in diode current vs. attenuation than at 400 megacycles (right) among three types of diodes.

The fringing capacitance is a constant, which can be found experimentally. A figure of 1.6 pf/in. is sufficiently close to use for lines with characteristic impedances, Z_o, between 30 and 100 ohms.

Diode capacitance is fixed by the type used. Most of those tried had a capacitance of 1.5 pf. Lower-capacitance units can be obtained, but at increased cost. It was found that the diode's capacitance could be considered as distributed over the length of the line used, without too large a percentage error.

$C_{dd} = NC_d/(N-1)L$ pf/in., where C_{dd} = distributed diode capacitance, N = number of diodes used and L = ⅛ wavelength in inches at the frequency of interest.

The prototype used

The prototype line used five diodes, each with zero-bias capacitance of 1.5 pf per inch, therefore $C_{dd} = 0.865$ pf in. From the relationship $C_{pp} = C_T - C_f - C_{dd}$, $C_{pp} = 3.73 - 1.6 - 0.865 = 1.265$ pf/in.

The standard formula for parallel-plate capacitance is given by

$C_{pp} = 0.225\ \epsilon\ (n-1)A/t$ pf, where n = number of plates, A = area of plate in square inches and t = thickness of dielectric.

For microstrip, $C_{pp} = 0.225\ \epsilon\ A/t$ pf, or $C_{pp} = 0.225\ \epsilon\ W/t$ pf/in., where W = width of microstrip.

Glass fiber of any thickness can be used, but in the developmental model $\frac{1}{16}$-inch board was used. To determine the width of the line needed for a 50-ohm impedance, the equation above can be rearranged to give $W = C_{pp}\ t/0.225\ \epsilon$.

For $\frac{1}{16}$-inch-thick board where $\epsilon = 4.9$,

$$W = \frac{(1.265)(1/16)}{(0.225)(4.9)} = 0.0715 \text{ inch}$$

In summary, for a characteristic impedance of 50 ohms, the line will be 0.0715 inch wide and diodes with capacitance of 1.5 pf are spaced 2.172 inches apart on a board 0.0625 inch thick.

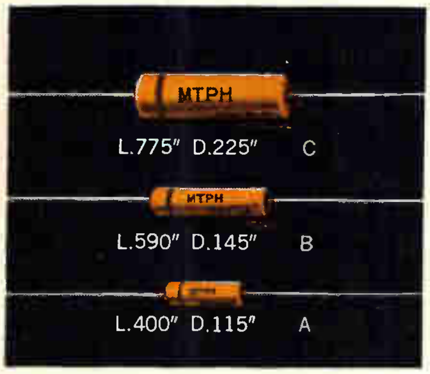
Units built in the laboratory were modified somewhat, because the impedance with which the attenuator was required to work varied from 35 to 65 ohms. A line width of 0.0625 inch rather than 0.0715 was found to give the most satisfactory results.

Calculations for a line 0.0625 inch wide, with no diodes mounted, gave a line impedance of 74.5 ohms. The measured value was 72 ohms, showing close agreement between calculated and measured values. The ground plane must be extended on each side of the stripline, at least twice the width of the line.

When good r-f techniques are observed and a careful choice of diodes is made, an attenuator with very low zero bias insertion loss can be designed. A rule-of-thumb figure for attenuation is about 10 decibels per diode.

In the final development model, Transitron SG5400 units were used. These diodes have high front-to-back ratio, low forward resistance, low spreading resistance (R_s) and, at zero bias, small depletion-layer capacitance. Because these diodes also have large breakdown voltages and large current-handling capability, it is possible to handle r-f power levels up to 10 watts c-w without any significant degradation of the attenuation or of the attenuator's insertion-loss characteristics.

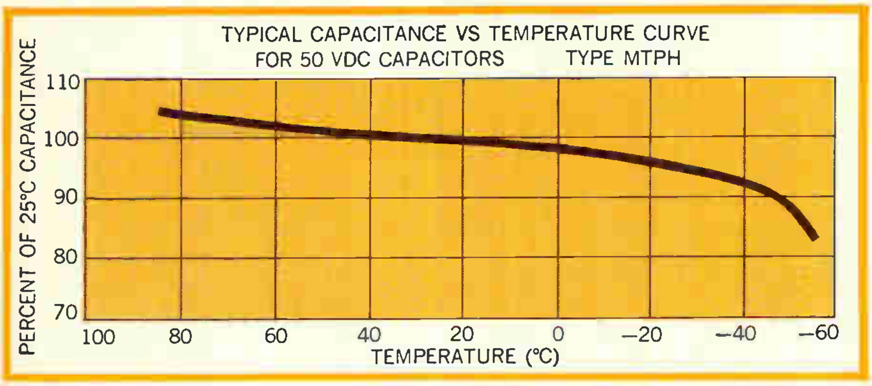
Miniature Wet Slug Tantalum Capacitors Proved by 3,500,000 Unit Test Hours

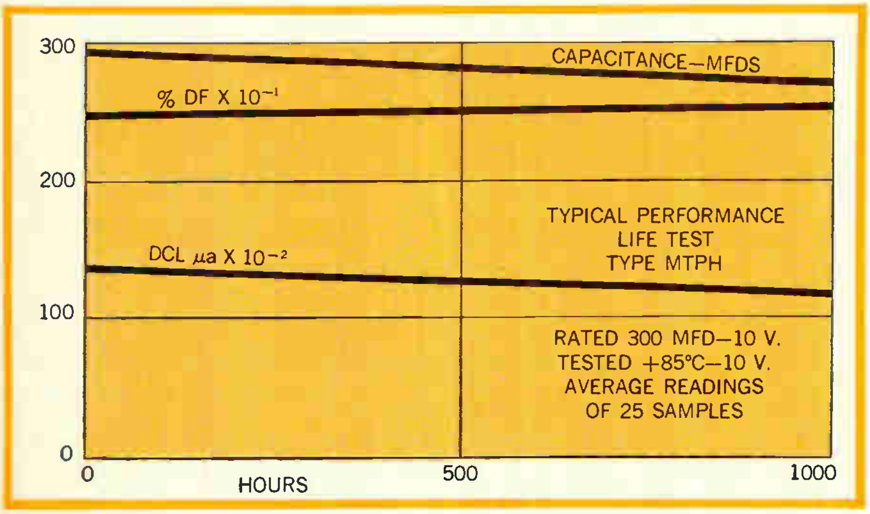


STANDARD RATINGS

MTPH NO.	Rated Cap Mfd.	Rated Voltage D.C.	DCL μa +25°C	DCL μa +85°C	DF% +25°C	% of +25°C Cap at −55°C	120 CPS Z at −55°C	DF% +85°C	Case Size
MTPH1	6.8	50	3	10	20	70	400	10	A
MTPH2	30	50	8	25	20	70	120	15	B
MTPH3	78	50	10	30	20	60	55	18	C
MTPH4	10	30	3	10	20	65	290	10	A
MTPH5	45	30	8	25	25	60	100	20	B
MTPH6	120	30	10	30	30	55	48	25	C
MTPH7	60	20	7	20	25	55	90	20	B
MTPH8	80	15	6	18	30	55	82	25	B
MTPH9	200	15	8	25	30	50	44	25	C
MTPH10	120	10	5	15	35	50	66	25	B
MTPH11	300	10	7	20	35	40	35	28	C
MTPH12	180	6	5	15	37	50	40	25	B
MTPH13	450	6	6	18	50	40	33	40	C

During 3,500,000 unit hours of life test at 85°C, at full rated voltage, using a low impedance power source, not one MTPH capacitor has failed through short circuiting or excessive DC leakage current. Type MTPH capacitors were developed by Mallory as a result of experience gained producing a similar line for use in the Minuteman II missile system made by Autonetics Division of North American Aviation, Inc.





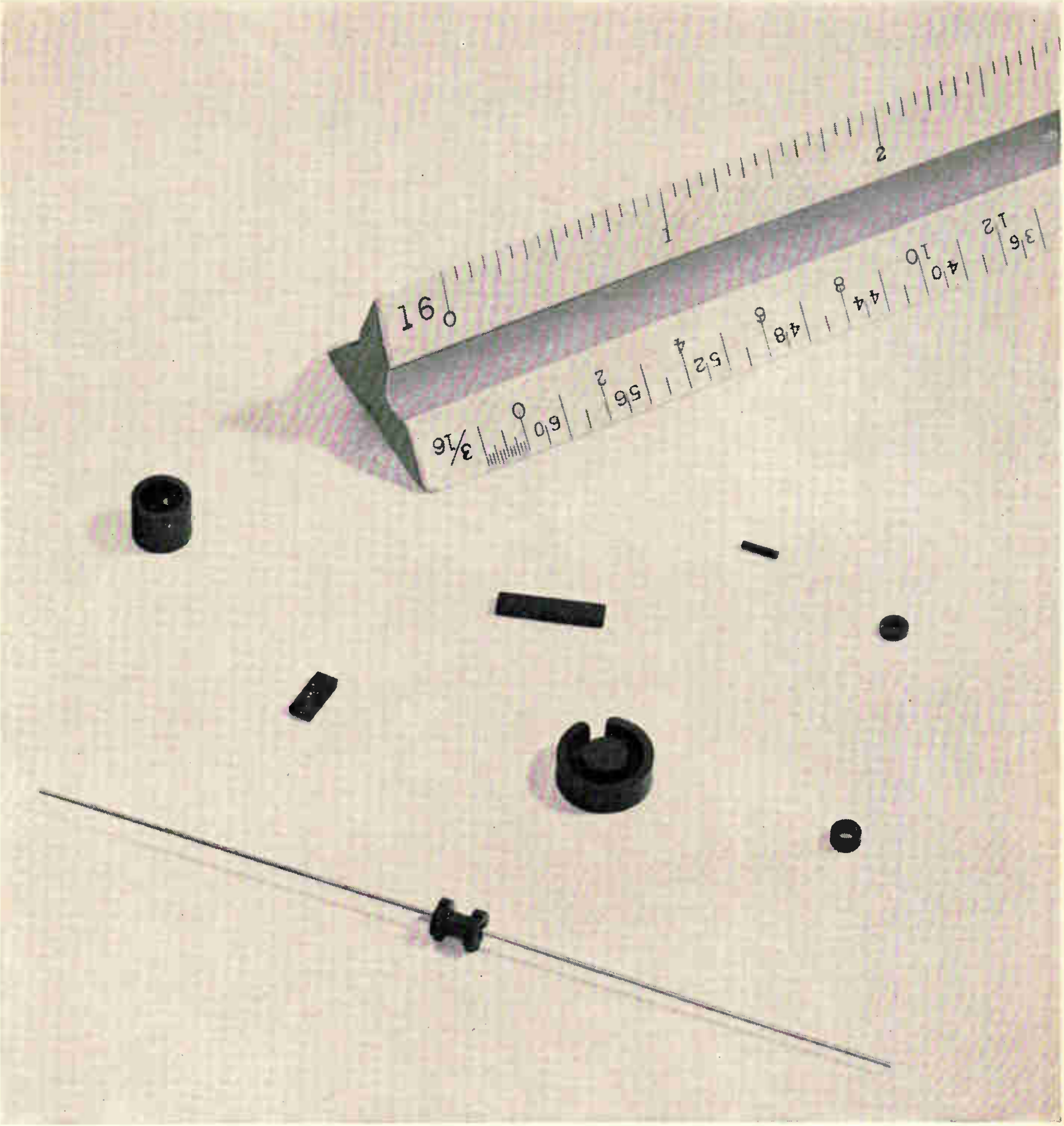
The MTPH style of capacitors are produced in the same "white room" manufacturing facility and by the same highly trained operators used for Minuteman II parts. The materials, production processes and quality controls are also the same, thereby assuring the highest degree of reliability.

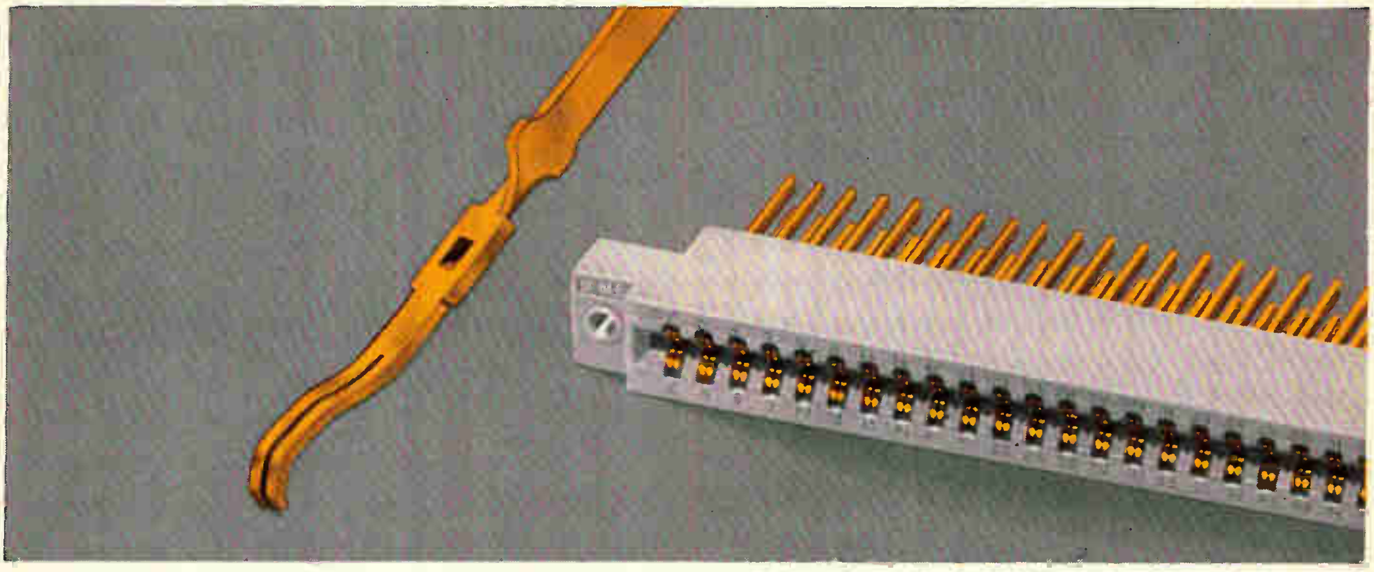
MTPH capacitors have higher capacity-voltage product per unit volume than any conventional wet slug, foil or solid tantalum line. This size factor makes these capacitors very desirable for applications with thin film, integrated and other microelectronic circuits. An additional advantage of the wet slug construction is the absence of the familiar catastrophic failure mode of solid tantalum devices.

For complete data and prices, write or call Mallory Capacitor Company, Indianapolis, Indiana 46206—a division of P. R. Mallory & Co. Inc.

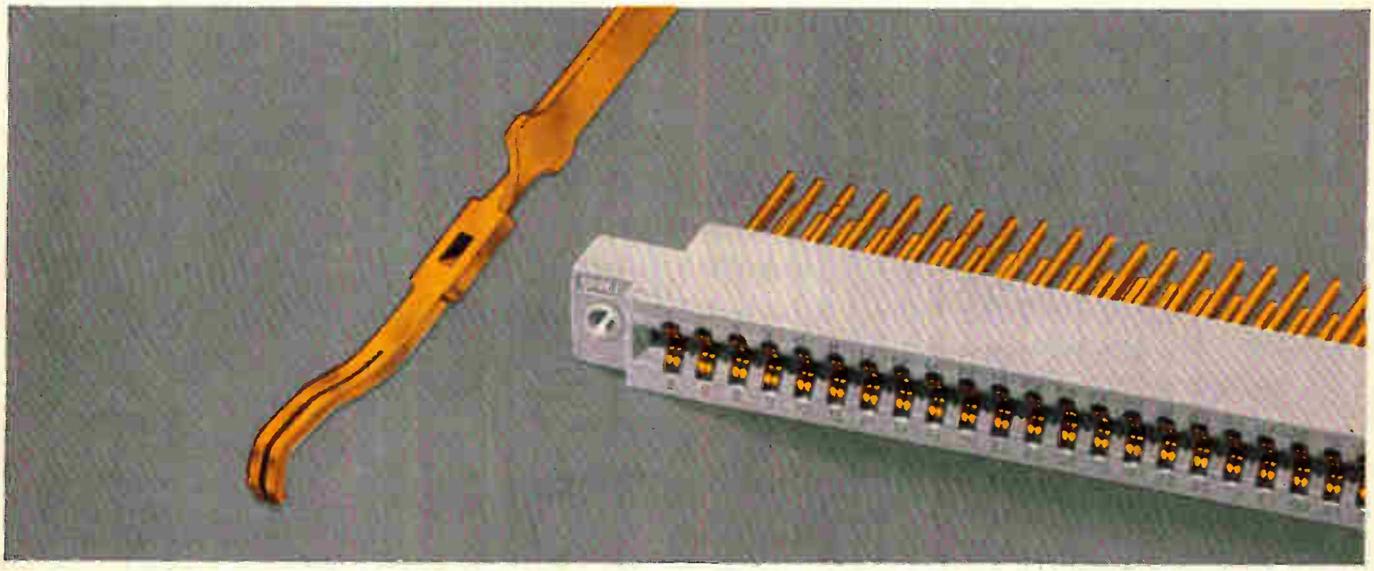
MALLORY

Circle 101 on reader service card





Pardon our redundance, but you asked for it!



We're referring to the contacts in our new TERMI-TWIST★ Printed Circuit Connector. In addition to all their other advantages, they're bifurcated for redundancy.

Now, with TERMI-TWIST contacts, you may use automated point-to-point wiring techniques and have the benefits of AMP's gold-over-nickel plating—plus contact redundancy. Yet, they're designed for cost savings from the front bifurcated contact through the center twist locking section right back to the rear post which accommodates AMP's new TERMI-POINT★ clip wiring devices.

For reliability, the phosphor-bronze contacts are plated with gold over nickel, including a .000030″ gold plating on the critical contact areas. Thanks to their 90° twist and square shoulder design, the contacts are positively aligned and firmly locked in the housing. Contact removal, however, is easily accomplished with ordinary long nose pliers.

These low-cost TERMI-TWIST Connectors are available in either diallyl phthalate or phenolic housings in sizes which include 15, 22, 31, or 43 contact positions, with contacts loaded on one or both sides. They are designed with a contact density of .156″ for convenient replacement of existing panel mounted connectors.

Take a look at these TERMI-TWIST Connector features:

- Economy—low initial and per-line cost
- Wiring compatibility—use TERMI-POINT clips; or solder, weld, or wrap
- Flexibility—accepts printed circuit boards from .054″ to .071″ thick
- Quality—meets mechanical and electrical requirements of MIL-C-21097
- Reliability—Gold-over-nickel plating and high contact force
- Versatility—optional automatic machine or hand tooling

If you've been asking around for an economical and reliable board edge connector that's compatible with automated application, don't overlook this TERMI-TWIST Connector. Write for complete details today.

★Trademark of AMP Incorporated

AMP INCORPORATED
Harrisburg, Pennsylvania

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A-MP★ products and engineering assistance available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • Mexico • Spain • West Germany

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You can help the balance of payments problem—and still have access to a global marketplace—by taking advantage of Northern Ireland's sweeping industrial development program. It is a program designed to get you into fast, efficient production in Northern Ireland at the least possible cost to you.

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To help you cut costs, the Government of Northern Ireland will give you outright cash grants or loans—grants toward your plant, machinery and equipment; you may even get grants on the cost of importing that machinery. And, we will make grants for training the men who will operate that machinery. The Northern Ireland Government may provide you a plant—new, modern, ready-to-go—for a rental as low as 2¢ to 3¢ per square foot per month, or custom-build a factory to your firm's requirements.

You will find that you are in good company in Northern Ireland. Our development program has attracted nearly 200 outside firms—firms like the Ford Motor Company's Autolite Division, Du Pont, International Telephone & Telegraph, Hughes Tool, Chemstrand (Monsanto). They have found Northern Ireland the strategic location to manufacture and sell to the world.

And we think you will like your other neighbors: the people of Northern Ireland. You and your firm will be genuinely welcomed in Northern Ireland—and we are willing to spend our money to prove it.

Full assistance and prompt answers to your questions are available right here in the U.S. from highly qualified representatives of Northern Ireland's Ministry of Commerce. Write or phone Jack Quan or George McLaren, British Industrial Development Office, 845 Third Avenue, New York, N. Y. 10022. PLaza 2-8400. Ask for our informative brochure "Produce in Northern Ireland . . . Sell the World Over."

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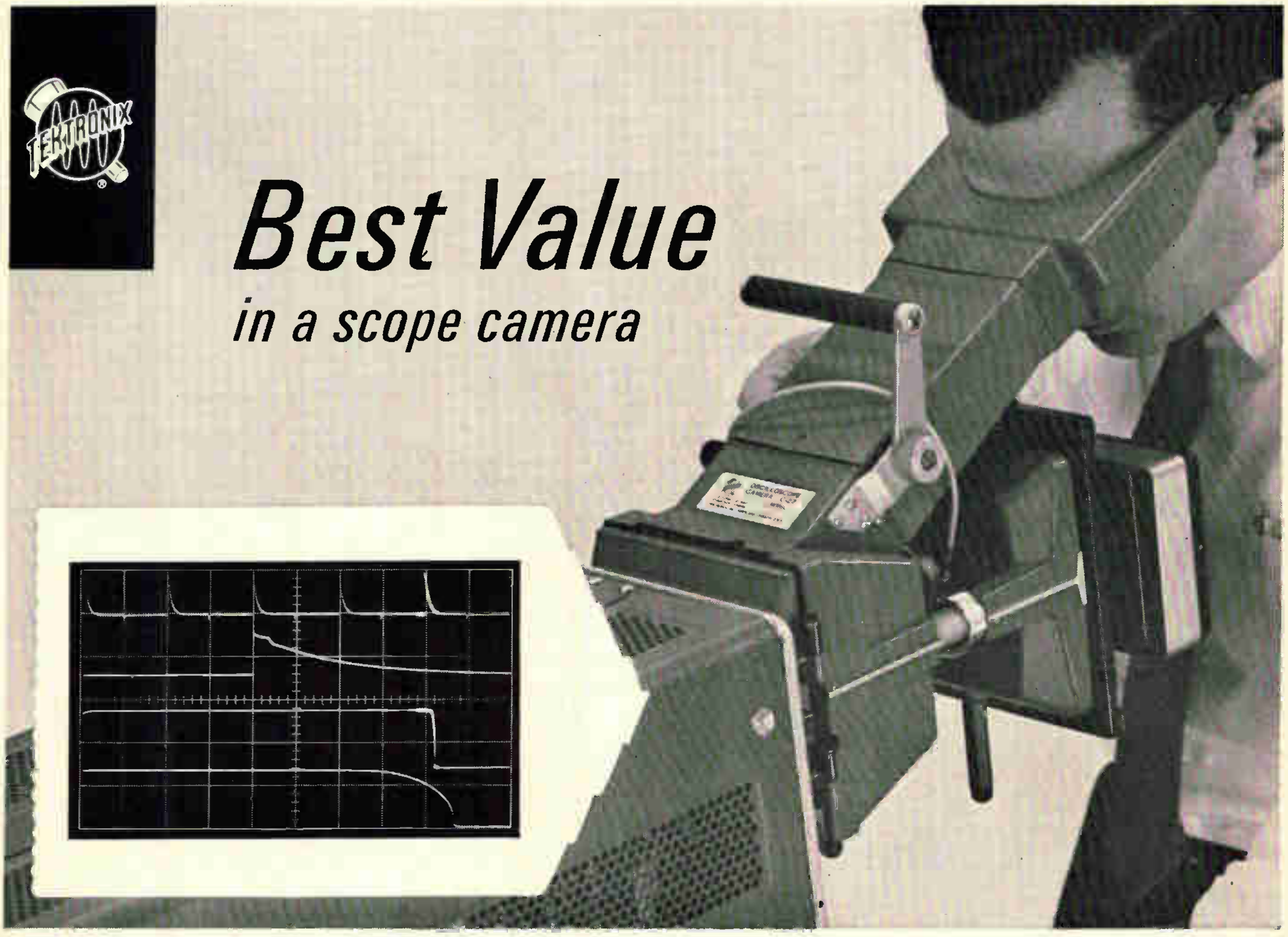

Best Value
in a scope camera

Combined features give the Tektronix camera highest all around performance

You can use Polaroid* film. Or, use other film, with a Graflock back.

You can interchange any of 7 lenses—f/1.9 (1:0.9), f/1.9 (1:0.85), f/1.9 (1:0.7), f/1.9 (1:0.5), f/4.5 (1:0.7), f/1.4 (1:1), and f/1.3 (1:0.5). Since the lenses are housed in prefocused and calibrated mounts with keyed threads, you can set the shutter speed and diaphragm opening quickly and simply. No confusion—for these controls always appear at the same convenient position.

You can focus with a single knob and lock the setting.

You can position the sliding back either horizontally or vertically. You can interchange any of 4 film-holding backs, and lock the film back in any of 9 detent positions to simplify multi-exposure photography.

And you get assistance when you need it—for full field engineering services back up every camera. For the complete story on this "best value" oscilloscope camera, call your Tektronix Field Engineer.

Tektronix, Inc.

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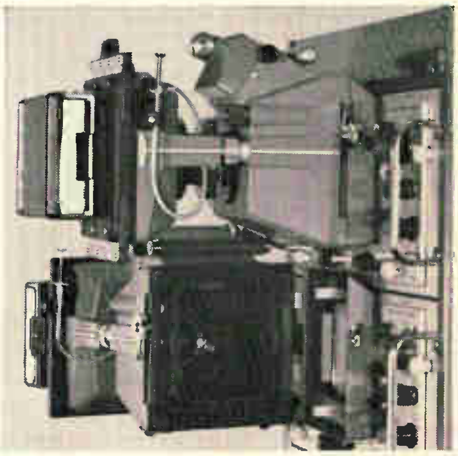

C-27 camera With viewing tunnels removed and carrying handles folded out of the way, the new C-27 Cameras can be stacked one atop the other—on such rack-mount oscilloscopes as the Tektronix multi-purpose Type RM561A (upper) and split-screen storage Type RM564 (lower).

Using shutter-actuator accessories with the C-27 Cameras permits simultaneous display recording.

Using optional Graflok backs and 4x5 film holders permits complete 10-cm by 10-cm display recording.

C-27 Camera, illustrated $420
Includes: f/1.9 lens (with 1:0.85 object-to-image ratio) complete with cable release, Polaroid* back, focus plate.

U.S. Sales Price, f.o.b. Beaverton, Oregon

*Registered by Polaroid Corporation.

Who says it costs

an arm

and a leg to get 22 watts at 450 mc... or 10 watts at 960

We've developed a new UHF power source for you designers of mobile communications gear, low-cost point-to-point microwave links and citizens band. It's simple, efficient and cheap, (yes, cheap). It uses a single Amperex power tube, the 8458, as a driver at 150 Mc., and a single varactor, the Amperex 1N4885 as a tripler. For 960 Mc., one more 1N4885 used as a doubler will provide 10 watts of output power.

The basic specifications of the 1N4885 are: Efficiency 70%, Breakdown Voltage 150 volts, Series Resistance 0.7 ohms and a Capacitance Range of 29 to 39 picofarads. The basic specifications of the 8458 are: Plate Voltage 600 volts, Plate Current 120 mA, Screen Voltage 180 volts and a drive power of approximately 3 watts.

If you can beat the watts per dollar you'll get from this combination of solid state and vacuum tube technology, you've got yourself a swell new job as head of our research and development lab!

For complete information, including an applications report on 8458 driver circuits and 1N4885 frequency-multiplier circuits and filter networks, write: Amperex Electronic Corporation, Semiconductor and Receiving Tube Division, Department 371, Slatersville, Rhode Island 02876.

IN CANADA: PHILIPS ELECTRONICS INDUSTRIES, LTD., TORONTO 17, ONT.

Amperex®

Did you know that 19 of the 22 major connector manufacturers recommend Buchanan® Crimp Tools? —the other three make their own.

The reason is simple. Buchanan tools can be used with almost *any manufacturer's* contacts. No need to replace the tool every time you use a different contact. Simply change the positioner in the head. By selecting the proper positioner, you program the tool to provide crimp depth, crimp location and point of ratchet release. As we do not manufacture connectors, the full focus of our research and design has been spent to produce these most valuable tools. When you buy from Buchanan you avail yourself of an experienced staff devoted exclusively to crimp applications and service assistance.

Buchanan tools are fully qualified to mil spec, proprietary and commercial requirements.

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ELECTRICAL PRODUCTS CORPORATION

a subsidiary of Elastic Stop Nut Corporation of America

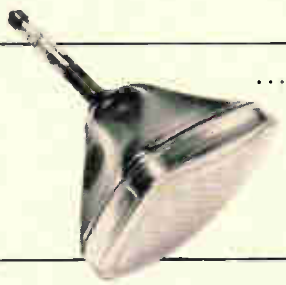
Circle 107 on reader service card

you won't look down

at the NEW Raytheon Side-View Numerical Indicator Tubes

Because of their unusual design, the new Raytheon digital, in-line miniature indicator tubes offer several important advantages over conventional top-viewing indicators. For one thing, their unit cost is lower. They require less mounting depth, allow close horizontal spacing and display large characters for the available viewing area.

These new Raytheon Side-View Numerical Indicator Tubes also feature conventional non-segmented characters for maximum readability, low power consumption, exceptional reliability and ultra-long life. Raytheon Side-View Numerical Indicator Tubes are available with numerals 0 to 9, characters + and —. Types with custom characters can also be provided. A mating Raytheon tube socket is available at low cost.



. . . MORE NEW RAYTHEON DATA DISPLAY DEVICES

New Datastrobe Digital Readout System (at right) features multi-digit display from a single light source, shared solid-state logic and true 4-bit BCD input . . . (Left) Special cathode-ray tubes, available in many sizes, combine electrostatic and magnetic deflection for writing alpha-numeric characters while raster scanning.

RAYTHEON

For complete information on RAYTHEON DATA DISPLAY DEVICES — or for an operating demonstration — write to Raytheon Company, Components Division, Industrial Components Operation, Lexington, Mass. 02173

SELECTED for MAJOR AEROSPACE SYSTEMS because of DRAMATIC SIZE REDUCTION and INHERENT RELIABILITY...

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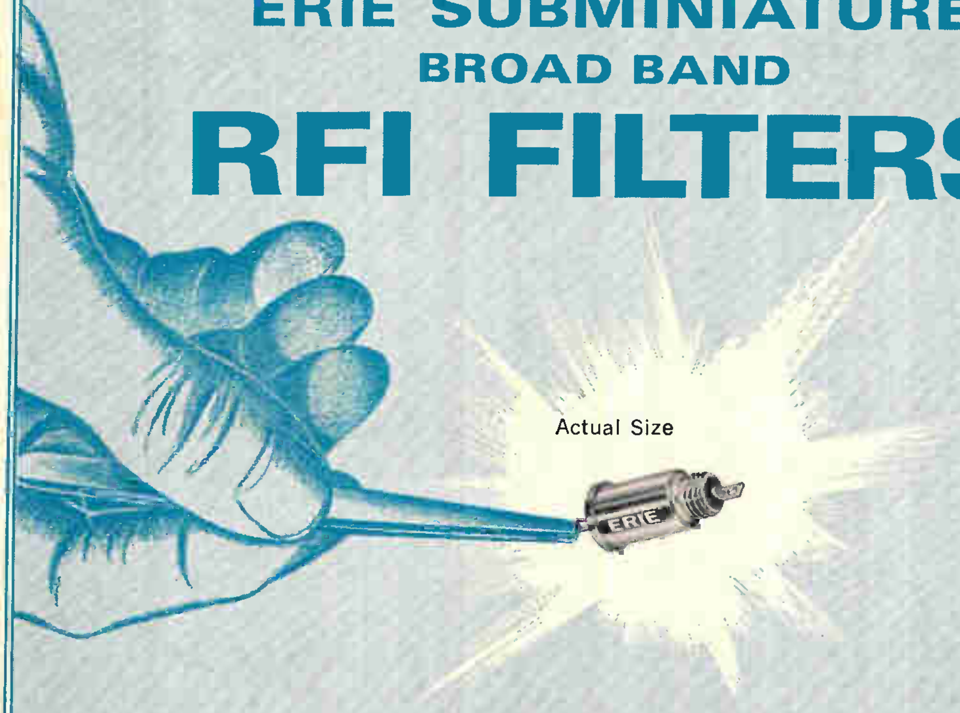
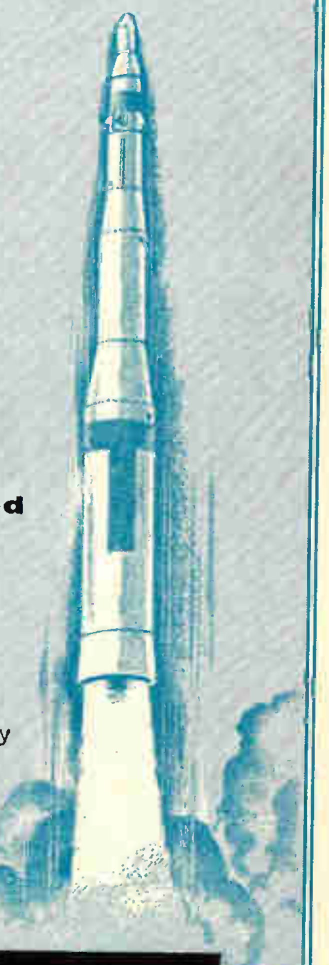
BROAD BAND
RFI FILTERS





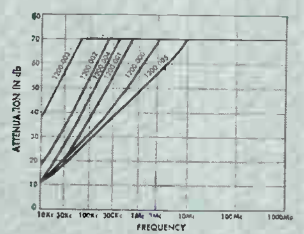
Exclusive! **High Attenuation • Hermetically Sealed Subminiature • Reliable**

Only one-fourth the size of conventional filters, Erie subminiature Broad Band RFI Filters provide excellent attenuation performance in the 10KC to 10KMC frequency range as shown in the attenuation curves below.

The problem of Electro-Magnetic Interference caused by switches, relays, motor commutators, SCR and transistor switching is efficiently eliminated by the use of Erie's hermetically sealed Broad Band EMI Filters. No longer is it necessary to use bulky paper capacitor-coil combinations . . . or large conventional filters. Erie filters provide better attenuation *in a fraction of the space.*

These reliable Broad Band Filters are selected for major aerospace systems as well as for use in industrial and commercial communication circuitry because of their small size (.375 dia. x .720 long) and high performance. Mounting arrangements and hardware to suit the application.

Consider the advantages of Erie Broad Band EMI Filters in your equipment. Write TODAY for literature and samples... Erie Technological Products, Inc., Erie, Pennsylvania.



TYPICAL ATTENUATION CURVE

Another series of components in Erie's Project "ACTIVE." Advanced Components Through Increased Volumetric Efficiency.

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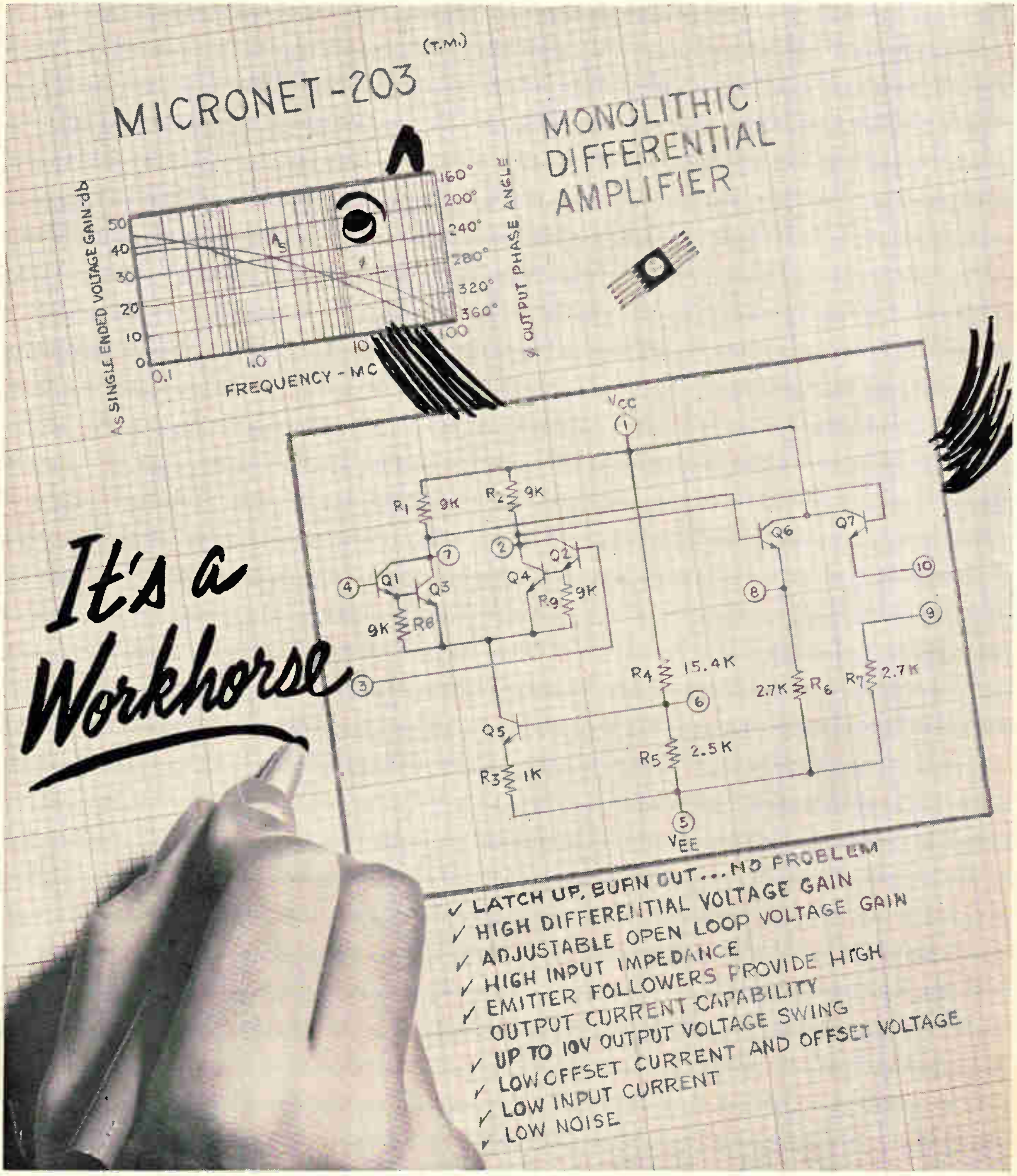

THIS INTEGRATED CIRCUIT IS A PROVEN MONOLITHIC WORKHORSE.

The Information and Communication Division of Sperry Gyroscope Company is one of the world's foremost users of integrated circuits. They have proved the reliability of Micronet-203 in critical applications. Used in DC and AC amplification, wave shaping, and buffering – these monolithic differential amplifiers have also carried their load in cost reductions. You can buy one of these beauties for less than $50 . . . or if you would like a hundred or so Micronet-203's, they're only $30 apiece.

☐ *Keep in touch with* **SPERRY SEMICONDUCTOR, Norwalk, Connecticut 06852.**

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Air Express outdelivers them all ...anywhere in the U.S.A.

Air Express
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(more basic facts about two more Hitachi silicon transistors)

2SC462
for
45 mc if amplifier

2SC463
for
vhf rf amplifier

★ forward agc current = 15 mA

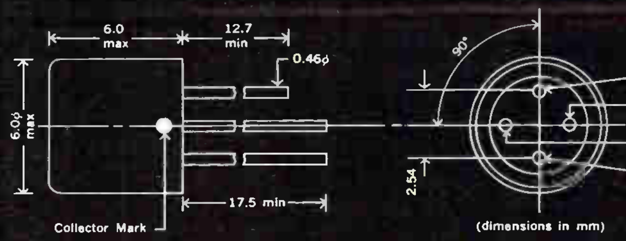
when PG† = −30 db

2SC462
- ★ PG† = 25 db at 50 mc
- ★ C_{ob} = 0.9 pF

2SC463
- ★ PG† = 14 db at 200 mc
- ★ C_{ob} = 0.9 pF
- ★ NF = 4 db at 200 mc

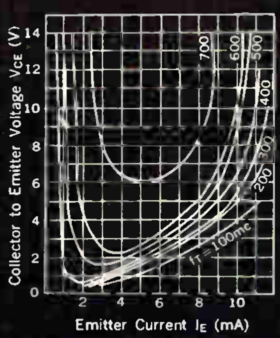
This family utilizes a hermetically sealed four-lead package which has a similar shape as the JEDEC TO-18.

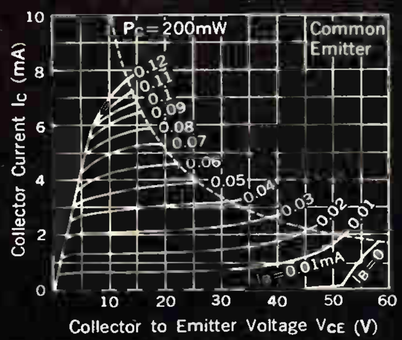
MAXIMUM RATINGS (T_a=25°C)	
V_{CBO}	40V
V_{CEO}	40V
V_{EBO}	4.0V
I_C	20mA
I_E	−20mA
P_C	200mW
T_j	200°C
T_{stg}	−55~200°C

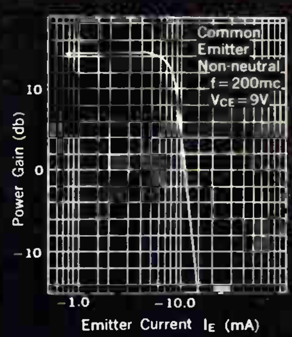


ELECTRICAL CHARACTERISTICS (T_a=25°C)		2SC462			2SC463			
		min	typ	max	min	typ	max	
I_{CBO}	(V_{CB}=20V)			0.5			0.5	μA
h_{FE}	(V_{CE}=10V, I_C=4mA)	—	50	—	—	50	—	
h_{fe}	(V_{CE}=10V, I_C=4mA, f=100mc)	4	6	—	4	6	—	
C_{ob}	(V_{CB}=10V, f=1mc, Shield Lead Grounded)	—	0.9	1.6	—	0.9	1.6	pF
NF	(V_{CE}=10V, I_c=4mA, f=200mc, R_g=50Ω)	—	—	—	—	4	6	db
PG†	(V_{CE}=10V, I_c=4mA, f=200mc)	—	25*	—	—	14	—	db
I_{agc}	(PG†=−30db)	—	—	—	—	15	—	mA

* value at f=50mc † Power Gain







Hitachi, Ltd.
Tokyo Japan

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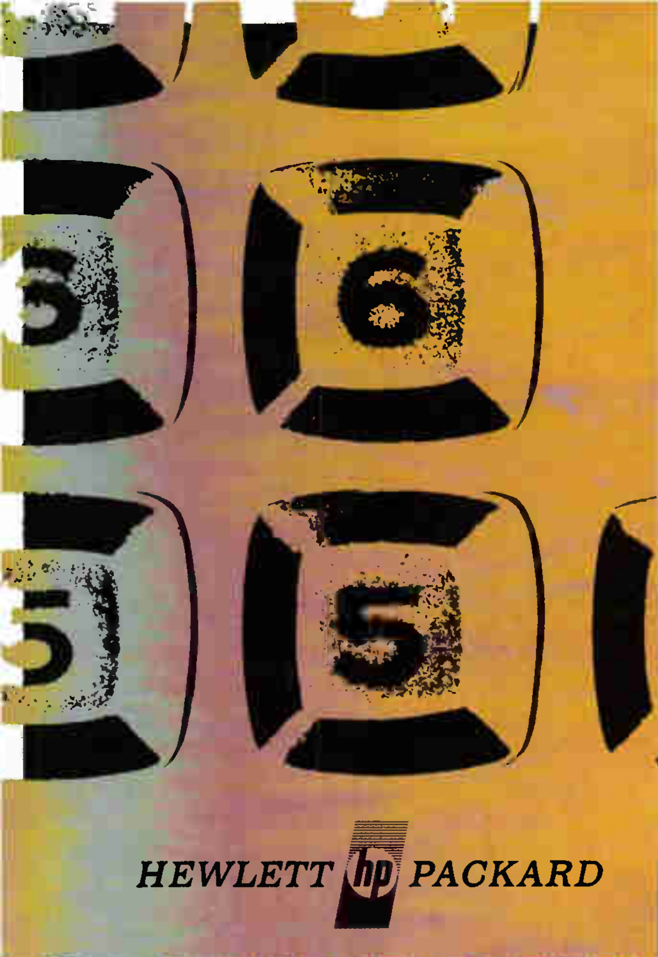

Two new Frequency Synthesizers from Hewlett-Packard

These solid-state instruments let you select output frequencies with switching time less than 20 microseconds. Spectrally pure signals are provided by a stable internal frequency standard, or you may use an external 1 mc or 5 mc standard. The Hewlett-Packard instruments employ a direct synthesizing technique, thus preserving the stability of the source standard. Signals may be selected by front-panel pushbuttons, remotely or by a combination of the two. Pushbutton selection is protected by a convenient lock system. A level control permits continuous adjustment of the output from 300 mv to 1 v rms. Rear-panel auxiliary outputs include a clean f_{out} +30 mc signal for use as a stable local oscillator and in application for multiplying to the microwave region. A search oscillator in each of the synthesizers provides continuous tuning of any selected column (by depressing the "S" button at the top of the column), plus an external sweep capability. Any significant column may be continuously "searched" from 100 kc to 0.01 cps (5102A) or from 1 mc to 0.1 cps (5103A).

The Hewlett-Packard 5102A and 5103A open new areas of application where the need for high-quality signals could be met only by instruments that were less compact, less versatile and considerably more costly. Use the handy postcard for complete information or write Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva; Canada: 8270 Mayrand St., Montreal.

PLEASE SEND COMPLETE TECHNICAL DATA ON

5102A ☐ ☐ 5103A

Name__________

Title__________

Company__________

Street__________

City__________

State__________ Zip__________

SPECIFICATIONS

Synthesizer	5102A	5103A
Output frequency	100 kc range: 50 cps to 100 kc 1 mc range: 50 cps to 1 mc	1 mc range: 50 cps to 1 mc 10 mc range: 50 cps to 10 mc
Output voltages	Continuously adjustable, 300 mv-1 v rms, ±1 db into 50-ohm resistive load; source impedance 50 ohms nominal (front-panel BNC)	
Auxiliary outputs	(1) Low level, dc to value of range, both ranges (rear-panel BNC) (2) f_0 +30 mc (f_0=selected frequency, dc to 1 mc, both ranges) (rear-panel BNC) (3) 1 mc frequency standard (rear-panel BNC)	
Auxiliary output voltage	(1) Low level 80 mv rms (min.) open circuit	20 mv rms (min.) open circuit
	(2) f_0 +30 mc: 1 v rms, ±2 db into 50-ohm resistive load (3) 1 mc: 1 v rms, ±1.5 db into 50-ohm resistive load	
Digital frequency selection	100 kc range: 0.01 cps to 10 kc steps 1 mc range: 0.1 cps to 100 kc steps	1 mc range: 0.1 cps to 100 kc steps 10 mc range: 1 cps to 1 mc steps
	(selection by front-panel pushbutton or remote contact closure)	
Switching time	<20 μsec for any change in frequency	
Search oscillator	Provides continuously variable frequency selection in any column over the complete range of that column; manual coverage by front-panel control or control by an externally applied voltage —1 to —11 volts	
Signal-to-phase noise ratio (output)*	100 kc range: >74 db; 1 mc range: >64 db	1 mc range: >64 db; 10 mc range: >54 db
Signal-to-AM noise ratio (output)*	100 kc range: >80 db; 1 mc range: >74 db	1 mc range: >74 db; 10 mc range: >74 db
Spurious signals**	100 kc range: >90 db; 1 mc range: >70 db	1 mc range: >70 db; 10 mc range: >50 db
Harmonic signals	>35 db on all ranges, all outputs	
Internal frequency standard	1 mc quartz oscillator	
Internal frequency standard aging rate	less than ±3 parts in 10^9 per 24 hours	
Stability of internal standard (as function of ambient temp.) (as function of line voltage)	±2 x 10^{-10} per °C from 0°C to +55°C ±5 x 10^{-11} for a ±10% change in line voltage	
External frequency standard	1 mc or 5 mc, 0.2 v to 5 v rms across 500 ohms	
Size	16¾" wide, 10-15/32" high, 16⅜" deep (425 x 266 x 416 mm) 75 lbs. net (34 kg), 127 lbs. shipping (58 kg)	
Price	$6500	$7100

*in a 30 kc band centered on the carrier, excluding a 1 cps band centered on the carrier, and measured on high-level output only
**below selected output for non-harmonically related signals

Litho in U.S.A.

Many of the outstanding achievements in science and technology during the past 10 years have been recorded, analyzed and preserved on tapes of "Mylar."* When reliability counts, count on "Mylar."

*Du Pont registered trademark for its polyester film.

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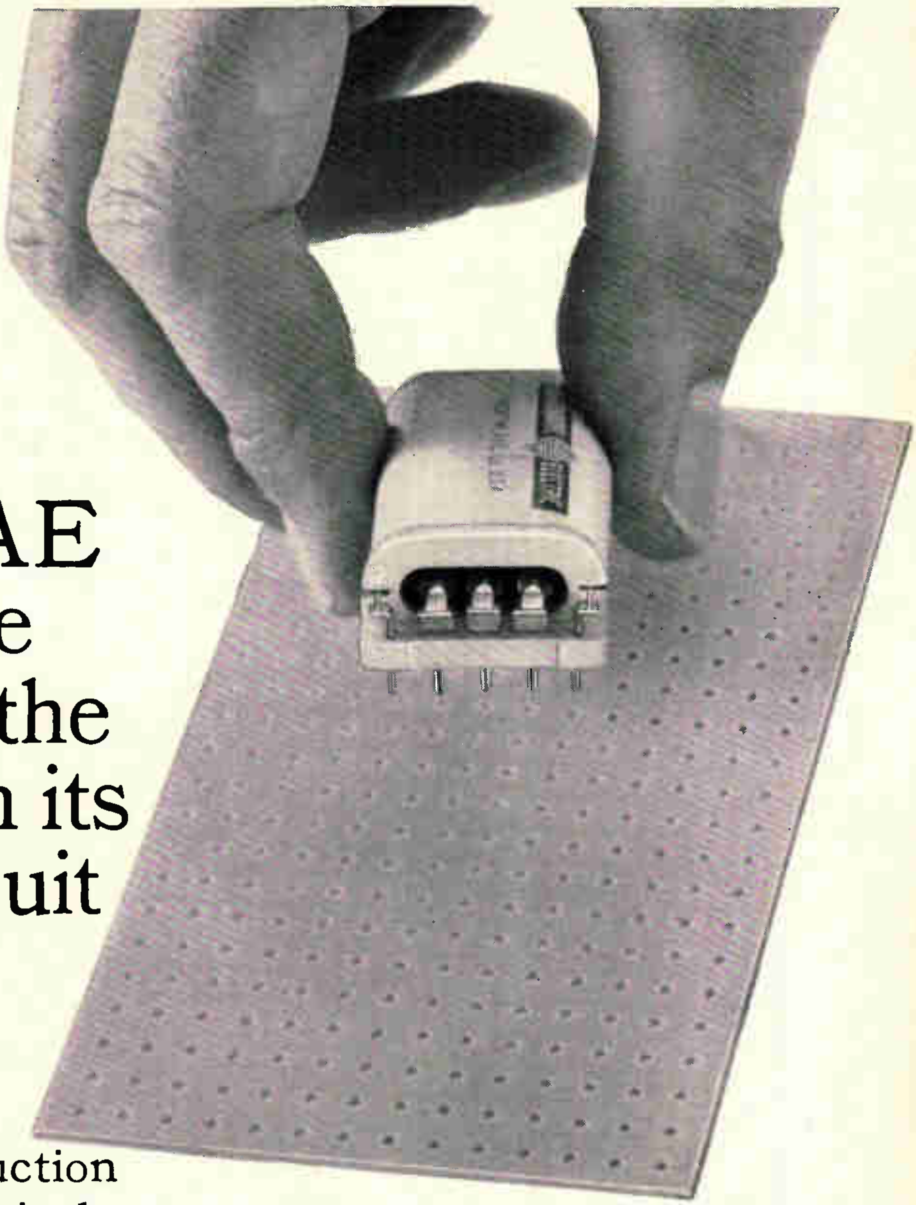
only DU PONT makes MYLAR® POLYESTER FILM

BETTER THINGS FOR BETTER LIVING ... THROUGH CHEMISTRY

Circle 115 on reader service card



Why does AE separate the leads from the terminals in its printed circuit dry reed switches?

Because this construction provides better electrical characteristics.

Should a capsule lead have to "double" as a terminal? *Separate* terminals give you superior electrical contact—and eliminate strain on the glass capsules. That's the AE approach on dry reed switches for PC boards.

AE also uses *welded connections* in these new PC Correeds*. The contact terminals are welded, not soldered, to the capsule leads. This reduces stress—makes more reliable connections, with greater mechanical strength.

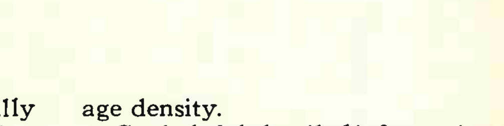
These switches are easy to insert. The terminals are longitudinally ribbed for extra strength and rigidity.

Bobbins are stronger too, because they're made of glass-filled plastic. Besides adding strength, this construction is moistureproof — to prevent electrical failure.

AE Printed Circuit Correeds are made to "standard" measurements: multiples of 0.200 inches between terminals, the industry standard for circuit boards. Standardized terminal size and spacing also allow for greater package density.

Get helpful, detailed information. Find out how new PC Correeds meet the requirements of modern electronic circuitry. Just write to the Director, Electronic Control Equipment Sales, Automatic Electric Company, Northlake, Ill. 60164.

2-capsule (Forms 2A, 1B, or 1A Mag. Latch) | 3-capsule (Forms 3A, 2B, or 1A-1B) | 5-capsule (Forms 5A or 2A-2B)



*U.S. Patent Pending

AUTOMATIC ELECTRIC

SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS GT&E

Military electronics

Electronics for American guerrillas

Unconventional warfare, behind enemy lines, requires new and better radios and other devices for our Special Forces and air commandos

By John F. Mason
Military Electronics Editor

The United States, which has been fighting a counterinsurgency war against guerrillas in South Viet-nam, is putting new emphasis on training guerrilla fighters itself, and on developing electronic equipment for them.

The program to outfit American guerrillas for the particular problems encountered in operating clandestinely in a "denied area" is moving on three levels: available equipment is being adapted to the new tasks, developmental gear is being tested, and new devices are being sought.

I. Air commando communications

One key piece of equipment is a powerful AN/TSC-15 radio, a high frequency, a-m/ssb transceiver that generates power up to 900 watts. It serves as the center of a communications web spun from the theatre headquarters of the air commandos, the Air Force Special Warfare men who fly the Army Special Forces to drop zones behind enemy lines.

The TSC-15 operates at from 2.0 to 29.999 megacycles, has three voice channels and four multiplex teletypewriter channels. It has two 32-foot fiberglass vertical antennas, one for transmitting simplex and duplex, and one for receiving in duplex only. The transmitting antenna may be changed to a long wire type for frequency stability.

Before the air commandos fly in

An acoustical telescope, made by Electro-Voice, Inc. for commercial use, is being tested by the Special Forces. The main problem so far is its inability to filter out unwanted sounds.

the Army Special Forces, they drop forces of their own to prepare the way. While on the ground, they need radios for three communications jobs: to talk with home base, with each other and the Army, and with aircraft. Now, three radios are needed. In the future, two will do the job, and later, one.

Point-to-point. To communicate with the TSC-15, the commandos will use the PRC-47 manpack, an h-f/ssb unit with a frequency range from 2.0 to 11.999 Mc. The radio has good power output (100 watts) but it is heavy; with accessories, it weighs 75 pounds, and with its watertight case, 175 pounds.

In a year, if design problems are straightened out, a 35-pound manpack, the PRC-62, will be ready to replace the PRC-47. Later, the PRC-70, a 30-pound transistorized transceiver that will replace many type of radios now operating in the field, will replace them both. Avco Corp. and the Electronics division of the General Dynamics Corp. are both developing the PRC-70 [Electronics, May 3, p. 63].

Troop-to-troop. To talk with the Army or with each other, the commandos use the PRC-25, a relatively new vhf/f-m solid-state unit that weighs 21.5 pounds. Later, the PRC-70 will probably take over the PRC-25's job along with that of the PRC-47.

Forward air controller. The ground-to-air radio now being used to talk with aircraft is the PRC-41, a uhf unit operating at from 225.0 to 399.9 Mc and weighing 45 pounds. Eventually this unit will be replaced by the long-suffering, now-terminated, though still not completely delivered, PRC-71.

The PRC-71, which began as the TR500A, a 37-pound unit built by Sylvania Electric Products, Inc., consists of four transceivers: vhf/f-m, vhf/a-m, f-f/ssb and uhf/a-m. The Air Force bought two of these for $200,000, and recommended that Rome Air Development Center get Sylvania to militarize the set and buy 40. After the set was ruggedized, it weighed, with case, bag and carrying kit, 55 pounds. The Air Force ordered 81, which will be delivered next month.

After working with the first batch of 55-pound units, the air commandos asked Rome to write specifications for a set that would weigh no more than 30 pounds, and as little as 25 if possible.

The new set will be called the PRC-72; other than being lighter and having a few more channels, it will be identical to the PRC-71. Both sets are unique in that they are designed to communicate with any radio used by any governmental agency of any country.

A number of companies submitted proposals to Rome. Three are still in the running, and the winner will be chosen soon. The first award will be for 30 units—an order that will take a year to 18 months to produce and deliver. If the specs are met, the Air Force will probably buy 5,000 sets.

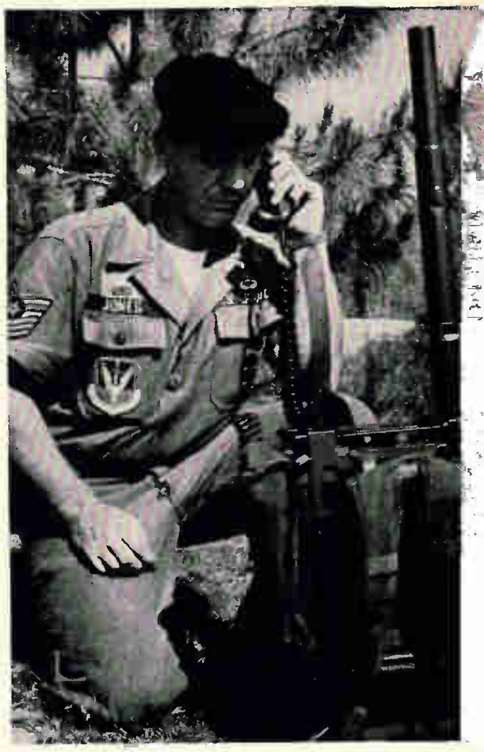
Future sets. Two expensive, highly sophisticated ground-to-air radios for forward air controllers are being developed, the PRC-65 and the PRC-66. Both sets use integrated circuitry and transistors. The "65" will weigh less than six pounds, the "66" less than seven.

One aid to point-to-point communications that will be tried soon is an F_1-F_1 radio repeater attached to a balloon that will be sent to 80,000 feet. To prevent winds from carrying the balloon away before it reaches this altitude, the whole system can be ejected from an aircraft at an altitude of 40,000 feet. Even then, wind will take it out of a useful position within four hours. Because of its short life, the equipment must be cheap.

II. Navigation

Today, the only means the air commandos have for navigating over enemy territory is pilotage—trying to match the terrain below them with a map. The 1st Combat Applications Group at Eglin, however, has just tested a doppler navigator (AN/APN-153), a computer (AN/ASN-25) and a gyro compass (J-4) housed in a pod attached to a standard 14-inch bomb shackle on a B-26. The system was developed by the General Precision Laboratory, Inc.

Although the concept worked well, the tests didn't meet the 1% accuracies the air commandos were hoping for. They believe malfunctions that can be corrected were responsible, and will run more tests.



The **AN/PRC-41** will be used by the air commandos to contact aircraft.

Beacons. To guide the air commandos back to a drop zone, homing beacons will be set up.

To date, however, neither the Air Force or the Army has written the final specifications on the homing beacons they want [Electronics, Sept. 7, 1964, p. 115]. Four low-frequency beacons are being tested at Fort Bragg, N. C.: the PRT-7 developed by the Army's Limited Warfare Laboratory at Aberdeen Proving Ground, Md.; the TRN-20, developed by Litton Industries, Inc. for the Air Force; the TRN-19 for the Marine Corps by Tridea, Inc.; and a new lightweight beacon, also by Tridea, the 111-900.

The Air Force, at Rome and at Eglin AFB, is testing both low-frequency and X-band beacons. One lightweight 1-f beacon Eglin just finished testing met requirements very well. Random malfunctions, however, spoiled the tests—due to the prototype's age, Eglin believes—and Rome has been asked to buy another unit. If it does, new tests will begin soon. The beacon was built by G. C. Dewey Co.

III. Guerrilla communications

The Special Forces have six communications requirements in an unconventional warfare mission:

This low-frequency radio beacon for guiding aircraft to a drop zone is the TRN-19, built by Tridea, Inc. It is one of four being tested by the Army.

Air commandos at home base will use this AN/TSC-15, an h-f/a-m/ssb radio, with power up to 900 watts, to talk with their men in enemy territory.

- The Special Forces operations base, located in friendly territory, needs to communicate with the Army, Navy and Air Force in that theatre of operations;
- The operations base must keep in contact with the Special Forces detachments training guerrillas behind the lines. (This could be a distance of several thousand miles; Okinawa might be the base for guerrillas in Communist China);
- The Special Forces detachments would need a radio to communicate with each other in the operational area;
- Each detachment needs a radio to talk with aircraft;
- Shortrange radios would be needed for the 12 men within a detachment to talk with each other;
- If war were declared, the detachments would need a radio to talk with the invading army.

Operations base. To communicate with the detachments as well as with the other military commands, the headquarters transmitter site has one MRT-9 van that houses three 500-watt T-368 transmitters, a trailer with two 10-kilowatt generators, and an array of half-wavelength dipole antennas. Located three to five miles away, so as not to pick up the transmitter signals, the receiver site has one MRR-8 van containing eight R-390 receivers, a control van with two teletypewriters, one reperforator transmitter distributor and a switchboard, two 10-kw generators, and an array of half-wavelength dipole antennas.

This equipment will eventually be replaced. Log periodic antennas are already available at the Special Warfare Center, Fort Bragg, N. C. to replace the half-wavelength dipoles. To change the direction of transmission of the half-wavelength dipole, the tower must be moved; to change the frequency, the length of the antenna must be changed. With the broadband log periodic, direction is controlled remotely by a motor and no change is required for different frequencies.

Every base station will have two log periodic antennas for the transmitters and two for the receivers.

New radio station. A new transmitter/receiver system, the TSC-26, will also be installed to replace the MRT-9 equipment at the transmitter site and the MRR-8 complex at the receiver site.

The TSC-26 will have more power—1.25-kw average output with a peak of 2.5 kw—than the present equipment, and it will have burst transmission capability. An entire message can be blurted in seconds, received on tape and later played back at normal speed. The station will operate at frequencies from 2.0 to 29.999 Mc. with capabilities for teletypewriter, voice, c-w and facsimile.

The TSC-26, built by Westrex Communications division of Litton Industries, Inc., will be field-tested at Fort Bragg this summer. First models will probably go to the field in November.

IV. Detachment radios

Right now, the AN/GRC-109 answers most of the communications requirements for the detachments in enemy territory. This equipment can communicate with the operations base, with other detachments, and with an invading army. The "109" is heavy. With accessories it weighs 85 pounds. It's an h-f, a-m radio with a 10-watt output that has been received 3,000 miles away.

Its primary mode is continuous-wave, for Morse code, but it will receive voice.

Ground-to-air. At present, the Special Forces have no single radio that will communicate with Army, Air Force and Navy planes. The ground-to-air radio they would take in would depend on which branch they would be working with.

The PRC-70 will communicate with planes from all three branches as well as fill most of the Special Forces' needs. Four models will be delivered to Fort Monmouth, N. J., for testing this winter.

Troop-to-troop. For communicating within a detachment, the Special Forces are still using the old PRC-10, a 35-pound f-m unit that has been replaced by the PRC-25. They are hoping, however, to be able to use a small six-pound ssb/f-m radio, called the PT-5 Field Mouse, that Avco Corp. is making. The Field Mouse generates 5 watts and will transmit for five miles. It is due for testing next March.

Antennas. In enemy territory, two kinds of antennas are normally used with the GRC-109: a slant antenna—a half-wavelength tied to a tree—for skywaves, and a long wire. The wire, which can be many wavelengths long, concentrates energy in a single direction, so that there is less chance for enemy direction finding equipment to pick up the signal. The long wire also is hard to detect from the air.

V. Other equipment

A number of devices are being tested at Fort Bragg and other Army centers that the Special Forces might be able to use. One is an acoustical telescope that amplifies sound at a distance. The unit being tested was built for commercial application and would have to be ruggidized considerably before the Army could use it. The problem to date is that it isn't very directional, and won't filter out unwanted sounds. Birds turn out to be terrible blabbermouths and often drown out significant sounds.

Equipment needs. The Special Forces need a number of devices they don't have.

- A good lightweight power supply.
- A passive beacon for guiding aircraft to a drop zone. This might be a small triangular reflector which could be hung in a tree, for a specific radar frequency. The radar would transmit briefly and only few times.
- A cheap receiver to give away to the local population to listen to music and propaganda. The device can't cost $10; fifty cents would be more like it.
- A device to detect an intruder. Many companies are working on this, with no good results to date. Thin wires that turn on lights and ring bells are also triggered by animals. One system requires buried wires that set up a magnetic field. An intruder would disturb this field. Burying wires, however, takes time and implies permanency. One possibility is a radio transmitter that would detect the presence of a human being by the capacitance effect. But this, too, would be affected by dogs and other animals, by wet ground and wind.
- A device to identify friends. This might be done by providing friends with an object to wear in their belt or pocket that would be detected by an electronic sensor.
- A navigation device for patrols.

Army and Air Force laboratories, which are working on these problems, would welcome more help from industry.

Contracts

Pentagon tries carrots

Value engineering may have its detractors, but the Defense Department is sold. Contractors who use the approach will be rewarded with a big share of the savings

Value engineering, the controversial method of saving money, is a success at the Pentagon and there's going to be a lot more of it. Earlier this month, Defense Secretary Robert S. McNamara ordered the employment of 265 additional value engineering specialists for the military services. This expansion will double the present staff and add $3.1 million to the payroll.

Defense contractors who attended seminars sponsored by the Defense Department recently, got the message directly from George E. Fouch, deputy assistant secretary of defense, and a key speaker in a five-city roadshow. He explained the new value engineering incentives that appear in the document known as Circular 11 and promised "real profit opportunities" to those who study and apply the new regulations.

George E. Fouch, deputy assistant secretary of defense, promises profit to contractors who get on the value engineering bandwagon

I. Cost reduction

McNamara is sold on value engineering and considers it an essential part of the Defense Department's cost-saving program which was inaugurated in 1962. Savings in fiscal 1963 attributed to value engineering amounted to $72 million. In fiscal 1964 that amount more than tripled; the total reached $250 million. Now McNamara is aiming for a goal of $500 million a year in value engineering savings by 1967.

Electronics firms have already reported some impressive savings as a result of the technique. In the AN/BQQ-1 transducer, where steel was substituted for bronze and the design simplified, savings to the Navy were a whopping $1,615,000. In another case, the elimination of an epoxy coating, specified for a circuit board for a fire-control computer, saved $60,000.

Dissenters. As an attitude, value engineering is as old as good engineering practice. In fact, its detractors say that only the name is new; that good engineering has always achieved what value engineering claims as its goal—to build the best for the purpose at the lowest possible cost.

Value engineers dispute this view. They describe their specialty, which was formulated in 1947 by Lawrence D. Miles, an engineer at the General Electric Co., as a formal methodology with a function-oriented approach. (They haven't convinced many electronics companies which aren't working on defense projects. Value engineering has yet to be widely used in nonmilitary electronics.)

Evangelism. One scoffer calls value engineering "an evangelistic approach" to electronics. And it is true that attempts to define value engineering produce some unusual bursts of eloquence which don't mean anything. For example, the latest issue of the Journal of Value Engineering contains a message by the editor of Tool & Manufacturing Engineer which says: "Value engineering confers to the

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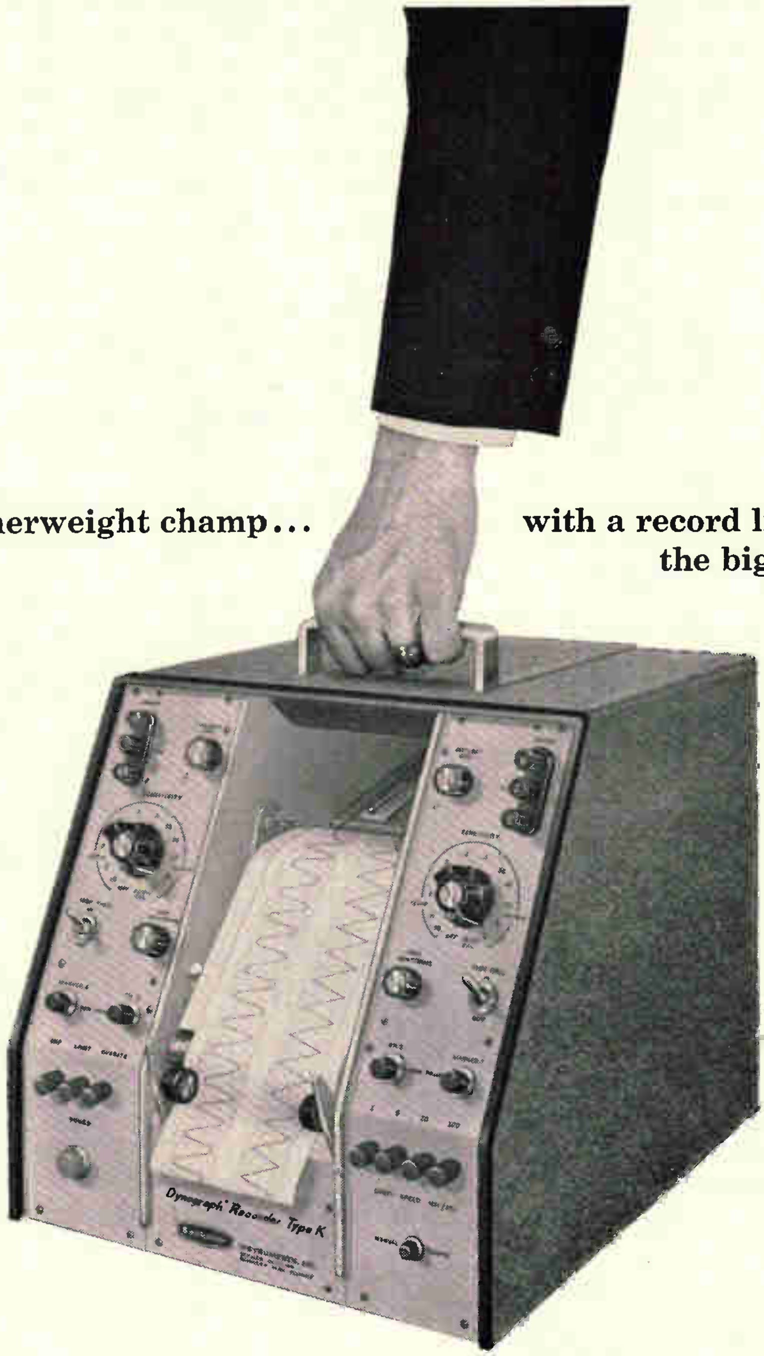

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Doubters. It is apparent that there are nonbelievers within the Defense Department and among its contractors. To them, Fouch recently issued a warning.

"There are some," he said, "who view value engineering as a mixture of do-goodism and hoopla, superimposed from above on hardworking and harassed design, production and maintenance people.

"Whatever the merits of this view, management should not allow such opinion to occlude its vision of real profit opportunities."

II. Vision of profit

It would take a severe case of myopia to overlook the reward for value engineering efforts in virtually all military programs. Defense procurement regulations encourage the approach with payments that can be as much as 50% to 75% of the savings.

Eyeopeners. Changes in the cost-reduction program have been rapid, but the most significant, to the contractor, are those which reward savings not only in current contracts but in follow-on procurement.

The new rules tempt contractors with a share in collateral savings—in operation, maintenance, logistic support—which result from the reduction in hardware costs. Additionally, they encourage subcontractor participation in value engineering by making it easier for the prime contractor to share rewards with the subcontractors.

III. Training programs

Last year, Space Technology Laboratories, a division of TRW, Inc., developed two courses for the Department of Defense—one on the principles and application of value engineering and the other on the management of value engineering in defense contracting. The courses, now available to all three services and the Defense Supply Agency, will answer the problem of training value engineers.

Not hit or miss. Practicing value engineers are usually alumni of in-company training programs. In most defense firms, value engineering is a staff function and seminars are used to train line supervisors and personnel in the specialty.

"There are 30 to 40 techniques in the concept," says Frederick S. Sherwin, of the Raytheon Co., who was among the first group of engineers trained at GE by Miles.

"It is a systematic method of looking at poor value areas. It is not hit-or-miss cost-cutting. It looks at the function, puts a dollar value on that function, explores various alternate ways of performing it, and puts dollar values on each new idea."

The team approach is used to attack areas of high cost. Robert J. Gillespie, who directs value engineering operations for the Electronic Systems division of Sylvania Electric Products, Inc., says line supervisors are trained to work with a value engineering point of view and to recommend areas for value engineering team efforts.

The first step. Additionally, companies emphasize value engineering as an initial step. It is most effective, says William M. Thompson, of the value engineering staff at Space Technology, "when applied by the cost generators themselves—the engineers who put a line on a drawing."

Space electronics

Airborne navigator for Apollo

Design is final and production will begin next fall on the space program's first self-contained guidance system

By Thomas Maguire
Boston Regional Editor

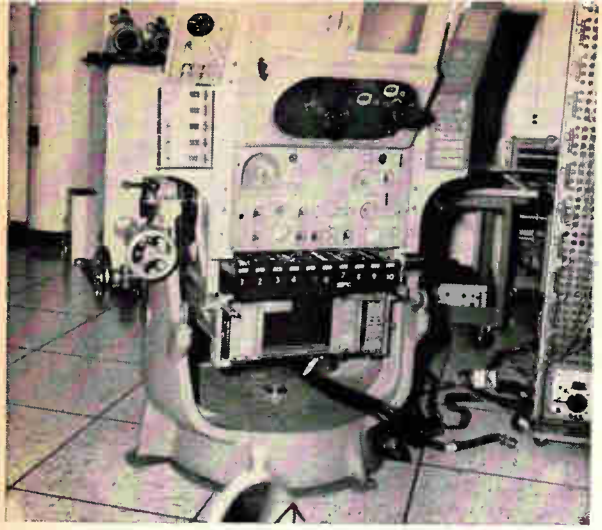
The equipment that will guide American astronauts to the moon and back has been designed in its final version, and production is scheduled to begin in the fall.

The first of three prototypes of the guidance and navigation system is being completed at the Instrument Laboratory of the Massachusetts Institute of Technology under the direction of Milton B. Trageser. All three will be evaluated at MIT and used to check test procedures.

Equipment for flight test and for the lunar mission scheduled in the late 1960's will be assembled at the AC Spark Plug division of the General Motors Corp. Meanwhile, production of an earlier version will continue. This preliminary model will also be used for flight tests.

1. Self-contained unit

Although the astronauts in Project Apollo will make full use of earth-based navigational aids, the guidance-navigation system will be capable of operating independently when necessary, for example when the spacecraft is behind the moon. The Apollo astronauts will be the first Americans to navigate in space, depending entirely on the instruments in the spacecraft to calculate their position in relation to the stars.



Early model of Apollo's guidance and navigation system will be produced along with the later version.

"All United States spacecraft, and as far as we know all Soviet vehicles, have been navigated using earth-based tracking measurements," says David G. Hoag, associate director of the MIT Instrumentation Laboratory.

Inertial guidance. Both the Command Module and the Lunar Excursion Module (LEM) will use modified versions of inertial guidance pioneered at MIT and used in about half of the inertially guided missiles in the United States arsenal. An inertial device performs two basic functions: it "remembers" its point of origin with reference to a fixed star, and it senses and measures changes in speed and direction. These functions are performed by gyroscopes and accelerometers. In the Apollo mission, the system will be used during accelerated flight.

When the spacecraft is beyond the influence of the earth's gravity and is "coasting" to the moon, an optical system will be used. This consists of a scanning telescope and a sextant that is made up of a star tracker and a photometer.

Distilling all this information into meaningful measurements is the task of the Apollo guidance computer, which also deciphers input from the landing and rendezvous radars in the LEM.

II. Two versions

After the basic concepts of the Apollo guidance and navigation system were defined in 1961, it was decided to design, build and test a preliminary system quickly, without waiting to incorporate any improvements.

By mid-1964, the prototype of this "Block I" system was operating [Electronics, Oct. 4, 1963, p. 14] and in production. Block I systems are now being ground-tested at various sites and at Apollo contractors' plants. Some of the systems will be flight-tested as soon as Apollo vehicles are ready.

Block II contains changes in Block I design and configuration. One change stemmed from the decision by the National Acronautics and Space Administration to use the lunar-orbit rendezvous and the LEM for a two-man lunar landing party, rather than a nonstop journey to the moon.

Both navigation systems will be produced. Although the production plan has not been disclosed by NASA, about 20 Block I systems are expected to be built, and 40 Block II's. NASA has estimated that the guidance and navigation part of Apollo will cost $400 million.

III. Design improvements

The most significant improvements incorporated into Block II are a computer that is more powerful but much smaller than Block I's; an all-electronic coupling-data unit to link digital and analog functions; and a smaller and lighter gimbaling system for remembering spatial orientation and measuring acceleration. Other changes are a star tracker and horizon photometer made part of the Command Module's optics, so that the earth's illuminated horizon can be used as a navigation aid; a digital autopilot for improved steering and attitude control; and moisture-proofing of all electronic modules.

Memory. The Block II guidance computer contains twice as much erasable memory as the Block I computer. There is also a 50% increase in fixed memory. Extra operation instructions increase the speed of the computer, so it can handle additional tasks in the control of the spacecraft.

The fixed memory consists of core rope, in which the program and fixed data are stored. A limited erasable memory for data consists of a ferrite coincident-current memory plane.

The Block II computer is smaller because of the use of NOR gates in flatpacks for the logic modules, and the high-density storage made possible by core ropes. The rope technique also enhances reliability, because loss of information is impossible without physical destruction of the wire's core.

Standardization. One of the most significant design decisions was to use standardized integrated circuits in the computer logic.

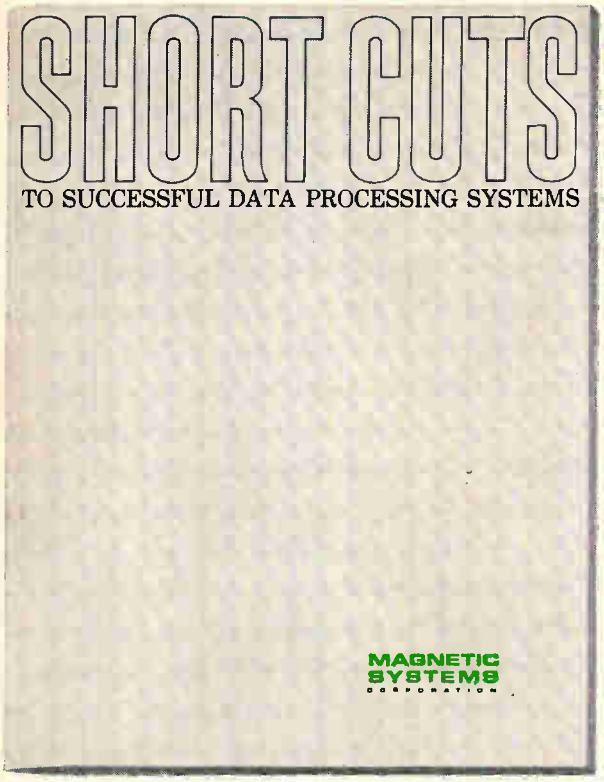
The decision to standardize circuitry was a step toward achieving the high reliability needed [Electronics, Dec. 14, 1964, p. 92]. Albert L. Hopkins Jr., assistant director of the Instrumentation Laboratory, who is responsible for design of the guidance computer, says: "Had a second type of microcircuit been employed, the number of logic elements could have been reduced by about 20%. But it is clear that to have done so would have been false economy. Neither of the two circuits would have accumulated the high mean-time-to-failure and high confidence level that the one NOR circuit has."

The standard circuit is a three-input, direct-coupled NOR gate. This consists of three transistors connected in parallel, with a resistor at each input. The circuit can drive as many as five similar circuits, and its propagation delay averages 20 nanoseconds.

Coupling-data unit. The standard integrated circuits are also used in the digital part of the coupling-data unit—a section of the Block II system that does the job of the mechanical gear trains, servomotors and digital shaft encoders used in the Block I system. The coupling-data unit, a combined analog-to-digital and digital-to-analog converter, connects the analog guidance and navigation equipment to the digit computer, and the computer to the rocket gimbals and other analog controls. Discrete components are used in the analog part of the coupling data unit.

Packaging. To prevent arcing—the discharge of static electricity caused by cabin moisture on electronic equipment—the electronics packages have been moisture-proofed, rather than merely made moisture-resistant.

In addition to AC Spark Plug, contractors for the navigation and guidance systems include the Raytheon Co. for the computer, Kollsman Instrument Corp. for the optics, and the Sperry Gyroscope division of the Sperry Rand Corp. for the accelerometers.



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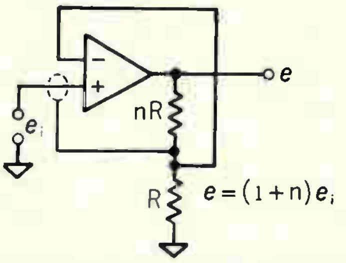

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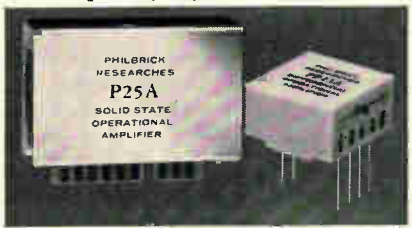

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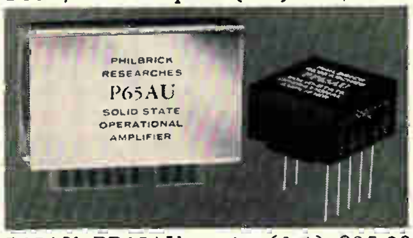

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INPUT IMPEDANCE >100 megohms
COMMON MODE REJECTION >10,000 : 1
PACKAGING compact plug-in and wire-in series available

P65AU, PP65AU (economy types)

ERROR CURRENT (when compensated) well below 100 nanoamperes
INPUT IMPEDANCE >20 megohms
COMMON MODE REJECTION >1000 : 1

*measured at 25°C

For complete information, consult your local Philbrick Representative or Philbrick Researches, Inc., 22-J Allied Drive at Route 128, Dedham, Mass. 02026 Telephone: (617) 329-1600

1.4 w P_{OUT}, 10 db P_{GAIN}, at 1 Gc

ACTUAL SIZE
High-mu nuvistor power triode (mu = 70); low-power cathode-drive Class C service in frequency range 400 to 1200 Mc; cw power amplifier, oscillator, frequency multiplier. Wt.—2.2 grams.

The new RCA-8627 nuvistor triode in 1000 Mc applications provides an overall output-to-input power efficiency of 33% and a plate efficiency of 40%.

Outstanding performance at a very attractive price...$8.50 each.

Current equipment manufacturers' bulk price in quantities of 50 or more. (Subject to change without notice)

To the circuit designer, the new RCA-8627 nuvistor offers all the benefits of the unique nuvistor concept of electron tube construction: es-entially constant transconductance over a very ide temperature range, dependable perform-nce in the presence of both pulse and steady-tate nuclear radiation, low RF noise, low sub-udio noise, 1000 g shock rating, high reliability nd exceptional uniformity of electrical charac-eristics from tube to tube and throughout life.

It also gives the designer the opportunity to assemble highly efficient, small-size and light-weight coaxial circuit configurations.

Be sure to evaluate the RCA-8627 nuvistor for any cathode-drive Class C 400-to-1200 Mc power amplifier, oscillator or frequency-multiplier applications. For more information, call your nearest RCA District Office or write RCA Commercial Engineering, Section F-19DE-4, Harrison, New Jersey 07029.

RCA-8627 cathode-drive amplification characteristics at 1 Gc

Power Gain	10	db
Useful Power Output	1.4	watts
Driving Power (approx.)	0.14	watt
Plate Efficiency (approx.)	40	per cent
Heater Power (150 ma at 6.3 v)	0.95	watt

RCA Electronic Components and Devices, Harrison, N. J.

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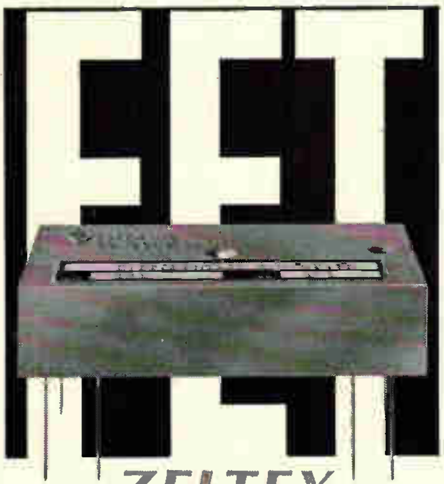
These are just two examples of Zeltex amplifier "Firsts." You are sure to find a Zeltex component that will match your performance, quality, and price requirements—Zeltex offers the industry's broadest line. Call your Zeltex engineering representative today!



ZELTEX

MODEL 131

Differential Operational Amplifier with FIELD EFFECT TRANSISTORS!

Input Impedance—3000 megohms!

- Input Current—1 nanoamp maximum!

Zeltex introduces the Model 131 differential operational amplifier—the first of its kind to employ field effect transistors to achieve exceptionally high differential and common mode input impedance with low current. Utilizing silicon transistors for highest reliability, Model 131 is offered in a small encapsulated model with machined connecting pins to facilitate etched circuit card mounting.

Key Specifications:

Gain: 100,000.
Gain-Bandwidth Product: 1 mc.
Offset Voltage: Adjustable to zero with internal potentiometer; 20 μv/°C and 50 μv/8 hr stability.
Input Current: 1 nanoamp maximum. Temperature coefficient of 0.1 na/°C (0°C to +40°C).
Input Impedance: 3000 megohms.
Output: ±10 volts, ±4 ma, frequency for full output of 80 kc.
Temperature Range: 0°C to +60°C.
Power Requirement: ±15 vdc.
Price: $125.

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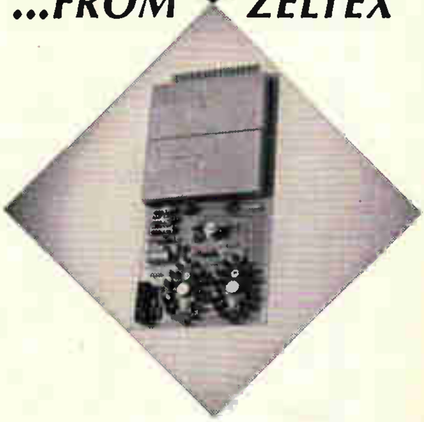


Solid-State Model 140B ±100 v Operational Amplifier for less than $100*!

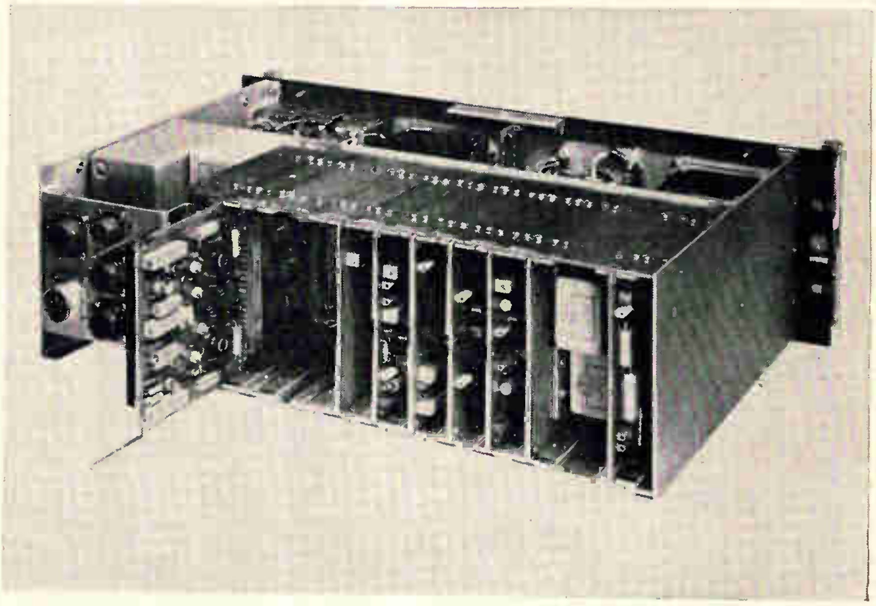
Say goodby to vacuum tubes. Zeltex can deliver from stock the new Model 140B, an all silicon solid-state operational amplifier with FET chopper, that delivers a full 200 volt output swing at 20 milliamperes for less than $100!
*(In quantities of 100 or more. $135 for 1 to 9.)

Compare these other key specifications: • drift of less than 3 μv/°C • built-in zero offset voltage adjustment • 10^7 DC open loop gain • 1.0 megacycle gain-bandwidth product • 30 pA input current offset with 5 pA/°C drift to reduce erroneous signal voltages.

So, say goodby to vacuum tubes—get the full story on solid-state Model 140B. Another first from Zeltex, technical leader in amplifiers and computer elements.

Circuit modules for infrared instruments

Company decides to market solid-state module devices originally developed for its own infrared detection equipment

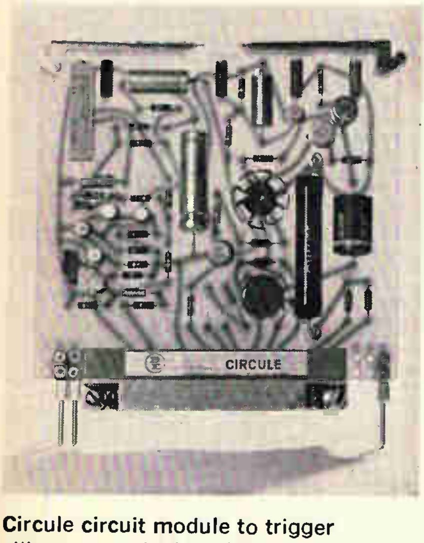


Circules in a research radiometer. Handles locked into place on boards swing out (board at left) for removal of board if servicing or replacement is required.

Equipment design can be vastly simplified and manufacturing costs cut if the designer can call on a ready-made module instead of having to choose many components. The Barnes Engineering Co., which makes infrared detection measurement systems, had been making circuit panel boards for its own equipment, and now has put the boards on the market. They are called Circules, a word coined from "circuit" and "module."

There are 24 different panel boards in the Circule line; each contains about 50 components. For example, the EC200, a general purpose amplifier, has 23 resistors, 14 capacitors, 8 transistors, 4 diodes, and 5 test-point plugs. Keyed connector pins prevent the modules from being inserted into the wrong slot in the equipment.

The modules were developed for use in space exploration equipment and industrial radiation-measuring instruments. Specific applications are in infrared radiometers, infrared dimensional gauges and cameras. The equipment is used to measure the diameter of glass tubing and to determine the temperature of wire cable and steel rods, and in a wide variety of reliability monitoring operations for both electrical and electronic components.



Circule circuit module to trigger silicon-controlled-rectifiers. It is one of 24 panel boards designed for infrared systems.

The Circule line has panel boards for bandpass and supersynchronous filters, synchronous demodulators, power supplies, a servo-amplifier, a reference signal generator, a thermoelectric power control and a circuit for firing silicon controlled rectifiers.

Barnes uses Circules in radiometers which make radiation and temperature measurements of distant objects, thermographs which show the distribution of temperature over the surface of objects, and equipment for automatically tracking high-speed missiles, rockets, drones, and jet aircraft in powered flight.

A typical Circule designed as a control circuit for firing silicon controlled rectifiers is shown in the accompanying illustration. The photograph of the Barnes R-8T2 research radiometer shows how the Circules slide into place.

The R-8T2 weighs 41 pounds and consumes 61 watts. An earlier version of the same equipment using conventional circuitry weighed 130 lbs and consumed 400 watts.

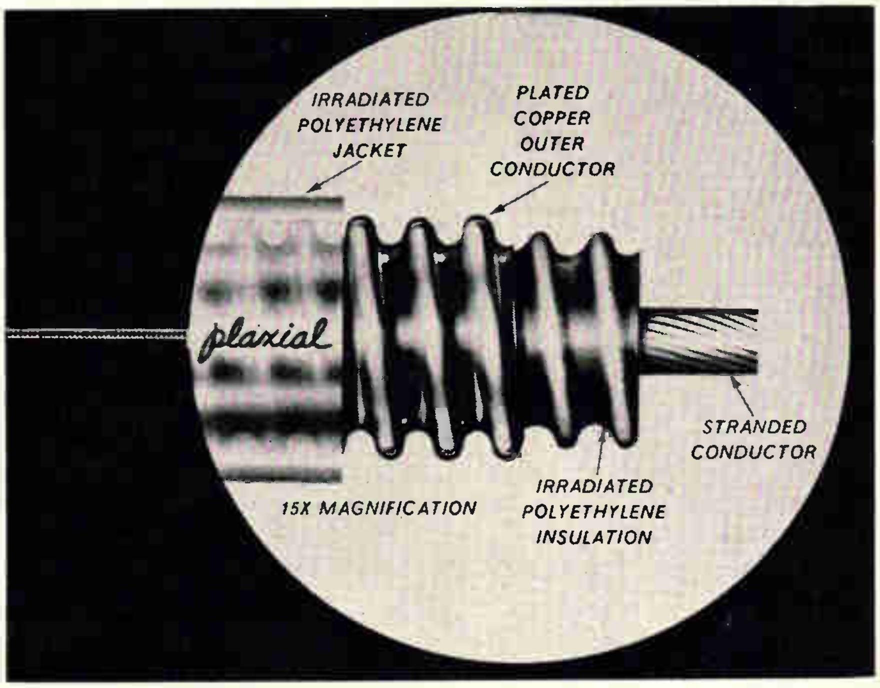
Specifications

Width	5 4/8"
Depth	4 11/16"
Thickness	3/32"
Connector contacts	15
Panel base	Glass-reinforced epoxy
Price range	$285 to $950

Barnes Engineering Co., Stamford Conn.

Circle **350** on Reader Service Card

Flexible co-ax cuts leakage



An extended helical outer conductor offers a solution to one problem that plagues small flexible coaxial cables: leakage and broken wires. The braided wires in conventional cable tend to snap when the cable is bent or twisted; and since it is hard to weave wires evenly around a small core, air holes often cause signal leakage at high frequencies.

Making the cable with a continuous outer conductor of thin metal has not been entirely successful because the sheath peels and cracks when the cable is bent. But polyethylene dielectric wrapped in a helix around the inner conductor and then coated with a thin copper film overcomes that drawback, because when the cable is bent, the helix moves like a bellows. The configuration is similar to that of conventional electrical B-X cable.

The metal outer conductor, 0.001 inch thick, adheres to the dielectric; since both move together when the cable is bent, the danger of cracking is minimized. Sharp bends do not affect characteristics, and impedance remains within specifications even when the cable is wound around a ¼-inch mandrel.

The transmission line, which weighs about 40% less than existing flexible cable, is said to reduce leakage at frequencies up to 10 gigacycles and to have more than 10 times the resistance to radiation damage of braided wire cables. The maker, Cinch division of United-Carr Inc., claims that the cable has better electrical properties than either rigid lines made of tubing or flexible lines with braided wire.

The cable, called Plaxial, is expected to find wide use in radar systems, communications satellites, and commercial high-frequency equipment. It has already solved problems for h-f systems used by the Army Electronics Command.

Specifications

Center conductor	27 strands of AWG #37 tinned copper wire
Dielectric	irradiated polyethylene
Outer conductor	plated copper, 0.001 inch thick
Jacket	irradiated polyethylene, 0.010 inch thick
Weight	0.01 lb per foot
Impedance	50 ± 2 ohms
Capacitance	32 pf per foot
Velocity of propagation	63.5% of free space velocity
Max operating voltage	3,000 volts
Attenuation	16 db per 100 ft at 400 Mc 57 db per 100 ft at 3 Gc
Price	about 55 cents per foot

Cinch division of United-Carr, Inc., 70 Jaconnet St., Newton Highlands, Mass. [351]

Circle 131 on reader service card

New Components

High-density series of push-pull connectors

The MARC 53 series is part of a completely reliable family of high-density connectors. The Lepracon, a member of this series, is reported to be the smallest high-performance multipin available today. The new series (high-reliability versions of the standard 43 series) feature Posilock coupling, a push-pull design that allows mating of the high-est density models with only fingertip pressure. In this design, a dual positive locking action eliminates accidental disconnect.

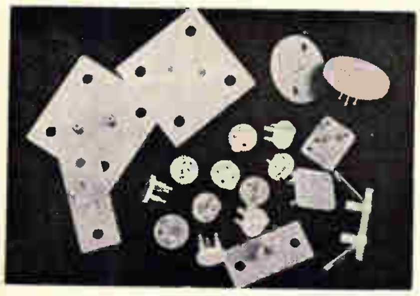
MARC 53 also features Posiseal, a multiple environmental sealing system said to provide an environmental integrity never before possible. The series has been designed to comply with the latest Air Force specifications, MIL-C-38300 Rev A. Microdot Inc., 220 Pasadena Ave., South Pasadena, Calif. [352]

Sealed relay bases have smooth contacts

A line of smooth contact, environmentally sealed relay bases is announced. Polarization and contact alignment is achieved by use of extended stud mounting hardware

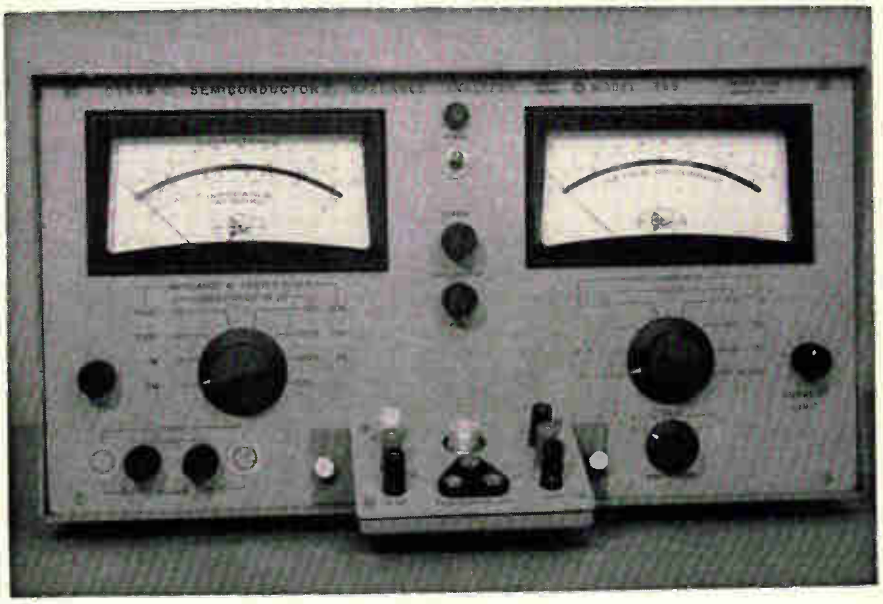
in conjunction with an alignment pin built into the relay header. This feature allows easy relay replacement in virtually inaccessible places. Sealing is accomplished by a resilient rubber grommet and a drawn aluminum compression cup. Sealing plugs are supplied to fill the voids where the customer omits contacts. The grommet is permanently bonded to the nylon body of the receptacle to provide pressure sealing of each wire, even if the back shell (compression cup) is not used in box mount applications. Designed to meet military specifications controlling relay headers, these bases will find extensive application where high reliability relays and timers are designed for use in airborne control systems. Solderless, crimp-type contacts conform to MIL-C-23216 and can be installed with the MS3191 hand tool or power tooling.
Burndy Corp., Norwalk, Conn. [353]

Transistor sockets offer reliability



Miniature printed-circuit type and chassis-mount type transistor sockets are announced for TO-3, TO-5, TO-8 and TO-18 transistors in a wide variety of panel materials, thicknesses and configurations. Over-all dimensions vary from ¼ in. high and ⅜ in. diameter upwards. All contacts are machined beryllium copper silver/gold finished. Terminations may be straight for dipsolder or with turret, solder pot or for rivet-in. Body material is normally G-10 glass epoxy. Lengths of leads may be accommodated from 0.125 in. upwards. The sockets, proven reliable under the most rugged conditions, are designed for use in airborne or severe-service applications.
Nugent Electronics Co., Inc., Box 486, New Albany, Ind. [354]

Transistor parameters measured at low signal levels by analyzer



Bootstrapped operational amplifiers can be used in a linear bridge circuit to measure semiconductor parameters at low signal levels. An instrument named the dynamic semiconductor impedance analyzer eliminates the distortion that occurs when general purpose bridges are used with high level signals.

In addition, Denro Lab's model 365 enables the designer to plot a complete family of characteristic curves in the same time it takes to obtain a few points with the bridge techniques. It is completely solid state, and measures current gain, dynamic junction impedance, and input and output capacitance at 100 kilocycles.

For capacitance measurements, Denro's analyzer provides a full-scale sensitivity of one picofarad with an applied voltage of only 10 millivolts. On the 30-picofarad scale and above, the applied test signal is kept constant at one millivolt. A metered internal power supply allows testing at bias values up to 100 volts d-c, either positive or negative.

The chopper-stabilized bias meter provides full scale current readings in seven ranges from 100 microamperes to 30 milliamperes and full scale voltage readings from 300 millivolts to 300 volts. The devices under test can either be plugged into a socket at the front of the instrument or tested in the actual circuit with a probe.

The instrument employs two operational amplifiers in a modified unbalanced linear bridge circuit driven from a stabilized 100-kilocycle source. The amplifiers provide both a constant low test voltage and a linear output that is proportional to admittance. One of the amplifiers follows the output of the 100-kc oscillator, while the other measures the voltage across one of a pair of matched precision resistors.

With no unknown connected across the test terminal, the voltage drop across the resistor is equal in magnitude but opposite in phase to that of the oscillator, resulting in no current in the bridge; hence, the meter reading is zero. When an unknown impedance is connected to the terminals, the voltage output of the bridge circuit will be proportional to the ratio between the resistance and the unknown impedance. This ratio is the unknown admittance.

The system is extremely linear

and sensitive, due to a large amount of current feedback (bootstrapping) around the operational amplifier loops. The guard system isolates stray capacitances from the test terminals. For example, when measuring impedance in a circuit with a remote probe, it is important to eliminate the cable capacitance so that no loss of sensitivity results. With the guard system of Denro's analyzer, the shield of the remote probe is operated at the guard potential, which effectively neutralizes capacitances up to several hundred picofarads. An additional convenience when measuring in-circuit parameters is that the chopper stabilized d-c meter provides a simultaneous measurement of the d-c potential as well as the dynamic impedance at the measurement point.

A d-c analog output is available at the rear of the instrument for go-no go limit sensing, or display on external monitors such as oscilloscopes, digital voltmeters and X-Y recorders. The model 365, working with a curve tracer, can present a display of the various dynamic parameters of a transistor as a function of polarizing voltages or currents.

Resistive and electronic current limiting is incorporated in the bias power supply so that the power dissipated in the device under test can be automatically limited to values as low as 100 milliwatts; thus avoiding damage to sensitive components.

Specifications

Capacitance ranges	1, 3, 10, 30, 100, 300, 1000 picofarads full scale
Accuracy	±3% of full scale +0.1 pf
Impedance ranges	3, 10, 30, 100, 300, 1000 ohms, 3 megohms center scale
Accuracy	±5% at center scale
Comparison measurements	To an accuracy of 1% of capacitance or impedance
Test signal: frequency	100 kc ±1%
amplitude	10 mv on 1, 3, 10 pf ranges, 1 mv above 10 pf
Internal bias supply	Continuously variable from 0 to ±100 v d-c at currents up to 10 ma
Size	17 in. x 9 in. x 9 in.
Weight	17 lbs.
Price	$955 (Model 365) $1035 (Model 365-1 with internal bias ramp generator for oscillographic display)
Delivery	2 weeks

Denro Lab, 1643 Forest Drive, Annapolis, 21403, Md. [381]

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Capacitance, 20 pF to 600,000 pF; capacitance tolerance from ±0.3% to ±20%; temperature coefficient, N100 and N150 ±50 PPM/°C; Voltage, 33 VDCW to 1000 VDCW.

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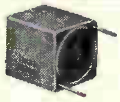

MIAL 603
Printed Circuit Mounting—
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MIAL 610
Sub-Miniature

MIAL 611
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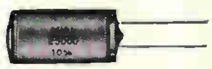

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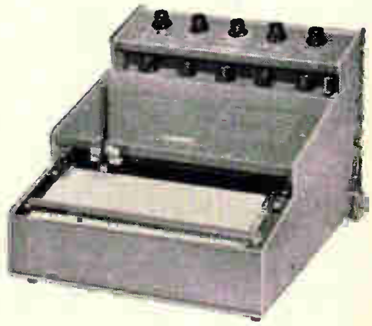
Assembled EUW-301, 26 lbs. $300.00



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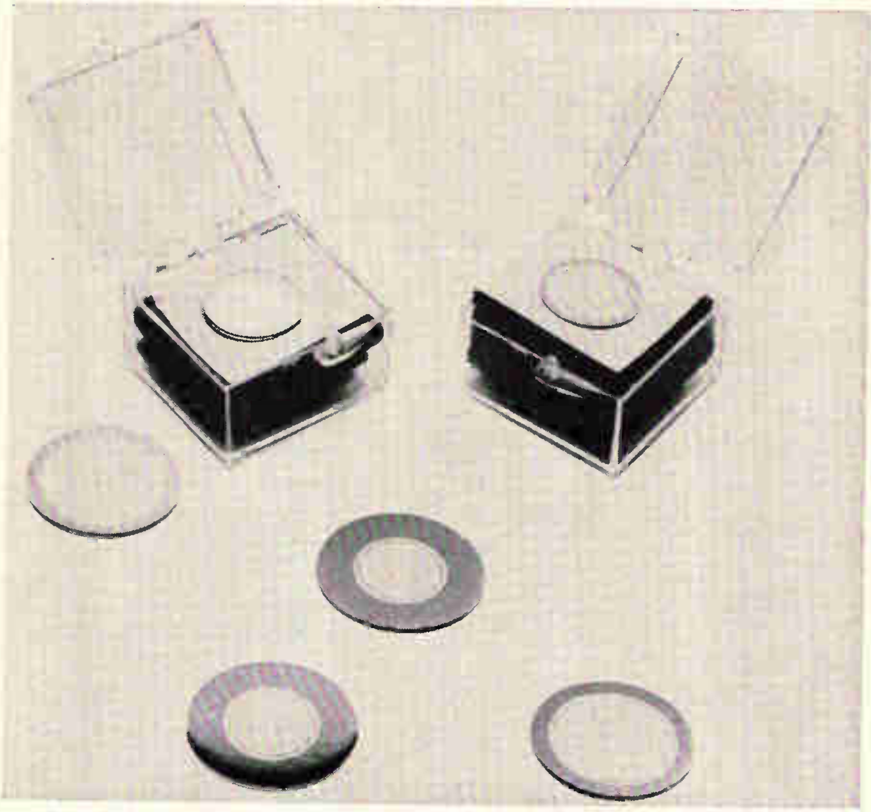


When a marketing survey showed that some government, industry, and university laboratories were making their own silicon radiation detector diodes because they couldn't find a supplier, Edgerton, Germeshausen & Grier, Inc., decided to fill the gaps.

The survey revealed that while some diodes were commercially available, they did not cover all detection ranges. Edgerton plans a custom-tailored service in which it will keep a line in stock to meet specifications supplied by the customer for the energy range of the particles being detected and the resolution level required.

The diodes have guard-ring construction, in which the active area is surrounded by an oxide-passivated zone. They provide typical energy resolutions of 20 to 25 kiloelectron volts.

Two families are available in the series. The more expensive DSG family is constructed with greater impurity diffusion depths, which provide higher accuracy in detecting radiation levels. The DSF family is for less critical alpha and beta detection applications.

The DSG devices are made from high-resistivity (2,000 to 5,000 ohms/centimeter) p-type silicon. The DSF detectors are made from p-type silicon having a resistivity on the order of 1000 ohms/centimeter.

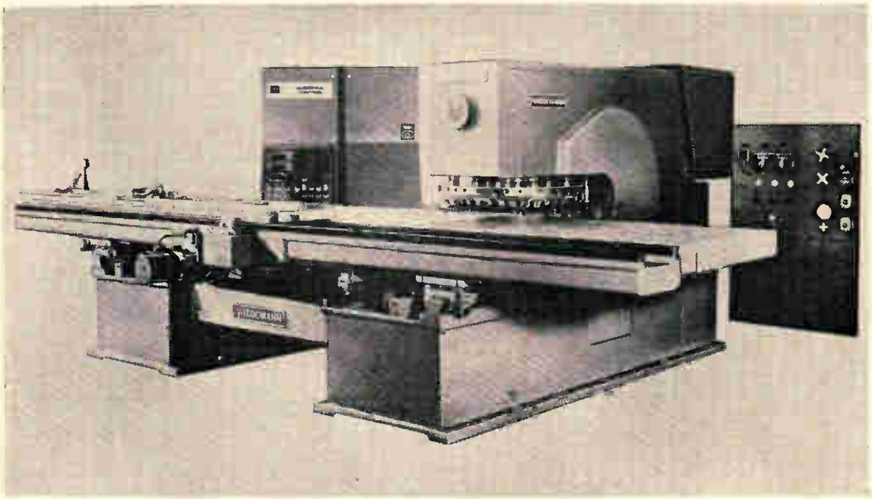
The devices may be operated at cryogenic or room temperatures.

Specifications

	DSG Series Min.	DSG Series Max.	DSF Series Min.	DSF Series Max.
Effective window (microns)	0.2	0.5	0.2	0.5
Depletion depth (microns)	100	600	50	250
Active area (sq. m.)	25	350	25	350
Energy resolution (Kiloelectron-volts, full width, half maximum)	30	15	30	15
Leakage current ($\mu a/cm^2$)	0.25	3.0	0.25	5.0
@ Operating voltage	100	250	100	250
Capacitance/cm² (pf) @ 100 volts	60	85	120	170
Price range	$120 to $610		$65 to $275	

Edgerton, Germeshausen & Grier, Inc., 160 Brookline Ave., Boston 15, Mass. [371]

Numerical control with memory



Control system (cabinet at left) will be used on large turret punch presses.

Two punched-tape readers, one of which acts as a memory for repetitive or computer-programed machining patterns, are built into a numerical control system for turret punch presses. Airborne Instruments Laboratory, a division of Cutler-Hammer Inc., says that this novel feature cuts by as much as 15 to 1, the time required to punch control tapes manually.

Detailed instructions for punching a frequently used pattern are programed on the tape for the auxiliary reader. The main reader's tape is programed with instructions for locating the pattern on the sheet of metal being punched and with the codes required to transfer control of the press to the auxiliary reader at the start of each pattern-punching operation. The same detailed instructions would be available for use over and over, for example in punching several radio chassis in a steel sheet, and would not have to be programed into the main tape to punch each chassis.

An initial contract for 10 of the all-transistor control systems has been received by AIL from the Wiedemann division of Warner & Swasey Co., which will use the controls on Wiedematic presses. A library of computer-prepared auxiliary tapes is available for punching large holes with these machines. Such holes are made by nibbling with a standard round punch at a rate of 100 hits a minute.

Called the model 902, the control system will be displayed for the first time at the Product Engineering Show, to be held in Chicago Sept. 19 to 29.

Specifications

Control type	Point-to-point positioning
Resolution	0.001 inch
X and Y motion	±98.999 inch
Turret positions	Up to 36
Positioning speed, max.	1,000 inches a minute
Production rate	Up to 115 hits a minute
Tape reader	Photoelectric, 300 characters per second
Tape input, coding, format	In accordance with EIA standards RS-227, RS-244 and RS-273

Airborne Instruments Laboratory, division of Cutler-Hammer Inc., Deer Park, N.Y. **[401]**

All-silicon counter has in-line display

This decade counter operates at rates from 0 to 50 Mc and displays the decimal count as accumulated. The display includes all decimal digits and the decimal point. Output carry and output BCD levels are provided. Since the circuit uses a common, rather than a ground, the drive signal may have an arbitrary reference level that matches the requirements of a wide variety of standard and nonstandard logic control levels.

This building block module is for high-speed timing systems, computer, industrial control systems, ranging and tracking systems or any application where the ability to count reliably at such high speeds is required, or where the counter must recognize single pulses of extremely short duration.

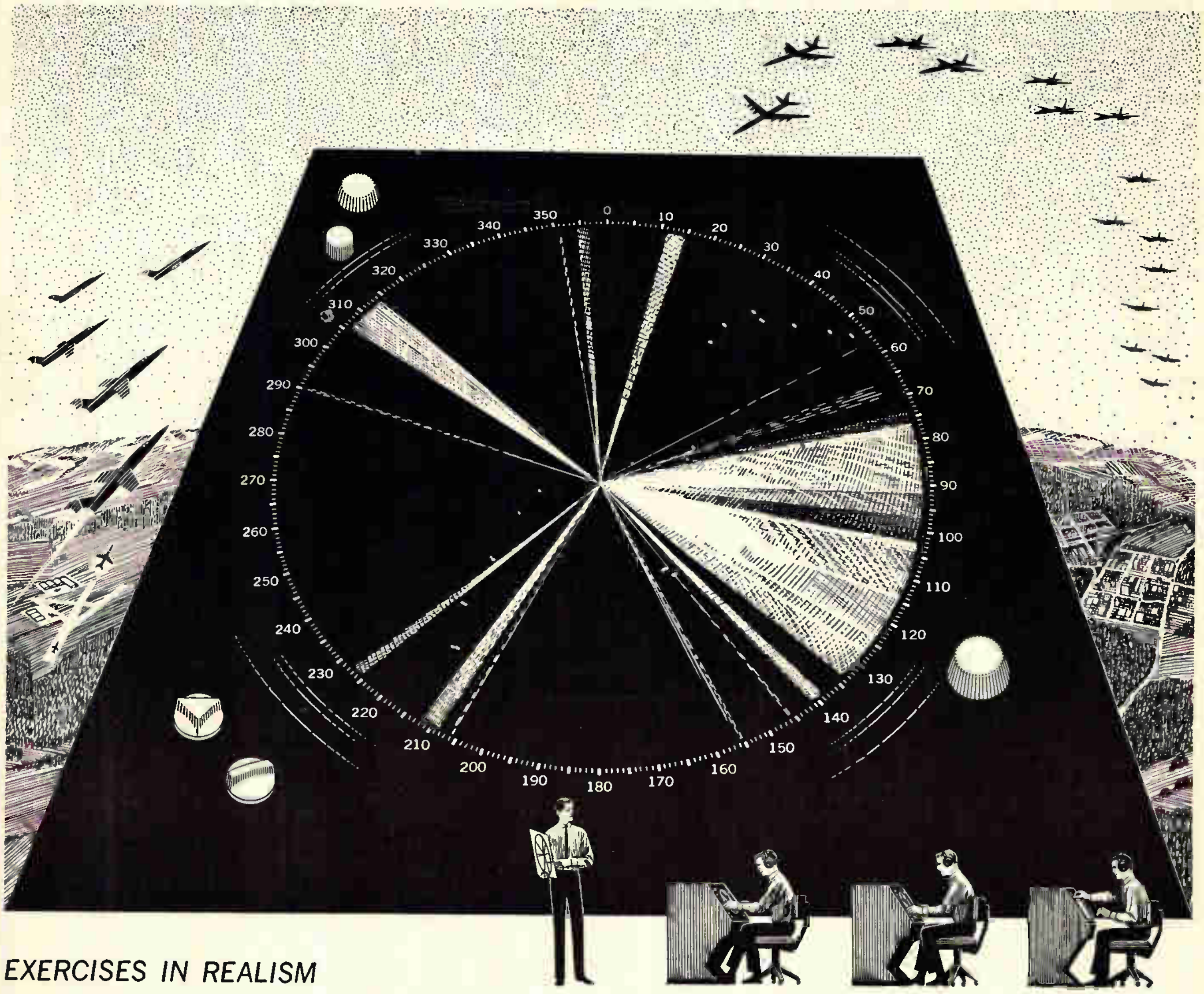
Model B-100-50 is a compact, highly reliable unit in a conveniently mounted, rugged case that measures 3 in. by 5 in. by 1 in. Operating temperature range is 0°C. to 60°C. Unit price is $142.50 in quantities of 55 to 99.

Janus Control Corp., Hunt St., Newton 58, Mass. **[402]**

Servo amplifier is small and light

A miniature servo amplifier has been announced for general application. The 400 cps unit was initially produced for missile and aircraft applications where size, weight, low cost and operation under adverse environmental conditions were of particular importance. The unit weighs 1 oz, has a volume of less than 0.8 in.^{3}, and a maximum power output of 3.5 w, with a factory preset gain of up to 4,000-1. It is capable of working to its specification within an environmental temperature range of -55°C to $+125$°C with a gain stability of ±1 db up to 60 db. It requires a synchro type mount for direct fixing to the gear plate.

Kollsman Instrument Ltd., The Airport, Southampton, Hampshire, England. **[403]**



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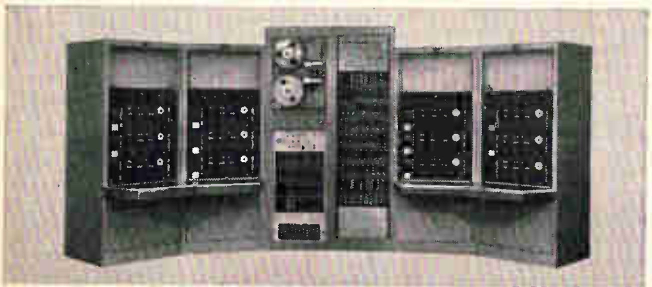
Developed and manufactured by the Pomona Division of The Marquardt Corporation, these advanced simulator-trainers are currently in operation in the USAF Air Defense Command and in such countries as Canada, Australia, Norway, Denmark, Germany, Greece, Turkey, Spain, and Portugal.

In addition, Marquardt is now producing for the Japanese Air Self Defense Force (JASDF) a complete nationwide air defense simulation system for use with Japan's BADGE network.



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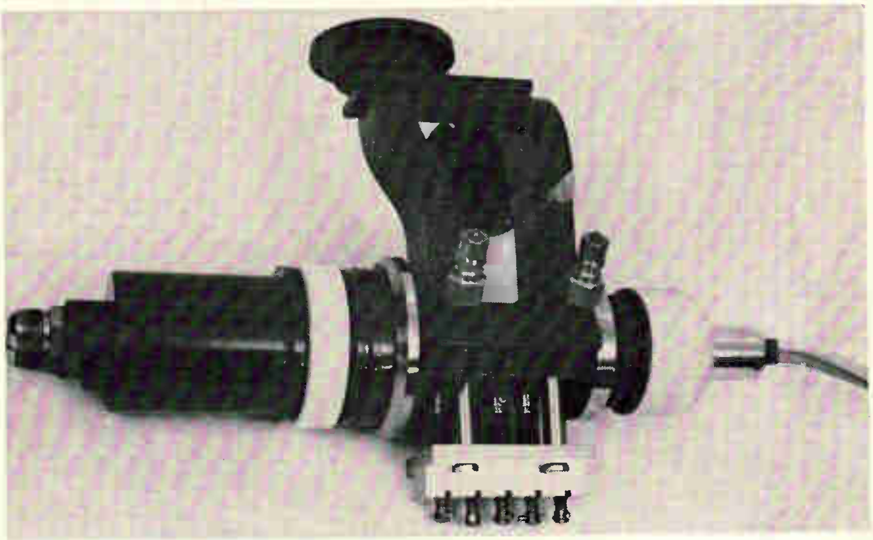
Klystron for satellite communications



Klystron amplifier offers wide bandwidth, high gain and efficiency in a small package. The tube is 16.3 inches long and weighs only 22 pounds.

A klystron amplifier that has the power output and the packaging simplicity needed for tactical earth-to-satellite communications has been developed by Varian Associates. Designated the VA-884, the tube is especially useful as a linear amplifier for single sideband signals. The klystron comes in two models: a regular "A" version, and a "B" model with a Vac-ion pump to remove gas caused by tube sparking.

The tube can be mounted and operated in any position. It may be positioned next to the driver in a ground control room, or mounted directly on an antenna and operated remotely from the control room. When it is remotely operated, the five cavities are ganged together and tuned by a Varian tuner mechanism, called VA-1481A, which consists of synchronous motors and electrically operated clutches.

The VA-884 may be tuned in three modes. In the synchronous mode, it is tuned for maximum gain by driving the tube with just enough input signal to cause a deflection on a power monitor at the tube's output. The cavities are then adjusted for maximum output power. As the power output increases (with cavity adjustment), the input drive signal level is reduced. This method of adjustment continues until maximum power output is obtained with the lowest possible input drive signal (usually less than 0.5 mw).

In the high-efficiency tuning mode, the tube is first synchronously tuned and the drive level is then increased by approximately 10 db. Cavities number 4 and 5 are then tuned for maximum power output.

The third mode, tuning for wide bandwidth, is more complex. First the tube is synchronously tuned, and then the drive power is increased to 4 milliwatts and cavity 4's turing shaft is rotated clockwise (the direction of increasing frequency) until maximum power output is obtained. Next the power input is increased to 16 milliwatts and the shaft of cavity 3 rotated clockwise to maximize power output. Finally the drive level is increased to 65 milliwatts, and the shaft of cavity 2 rotated counterclockwise, for maximum power output. This method yields a bandwidth of approximately 35 megacycles at the 3 db point. In this mode, the tube gain is about 53 db, and amplitude response is extremely flat and independent of input drive level.

Varian sells the tube for $12,515. Delivery is in 90 days.

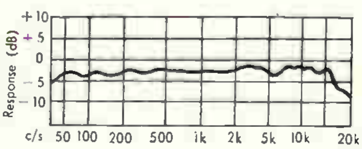
Specifications

Frequency	5.925-6.425 Gc
Power output	10-20 kw
Drive power	5 mw min., 200 mw max.
Gain	55 db avg.
Efficiency	40%
Bandwidth	
1 db point	14 Mc
3 db point	20 mc
Load vswr	1.05:1
Beam current	30 amps d-c
Body current with drive	30 ma d-c
Beam voltage	18 kv d-c
Heater voltage	8 ± 0.5 v
Heater current	7 amps
Cooling	Glycol/water
Focusing	Electromagnet
Voltage	2.6 vdc
Current	7 amps d-c
Mounting position	Any
Coolant	Glycol/water at 0.6 gpm

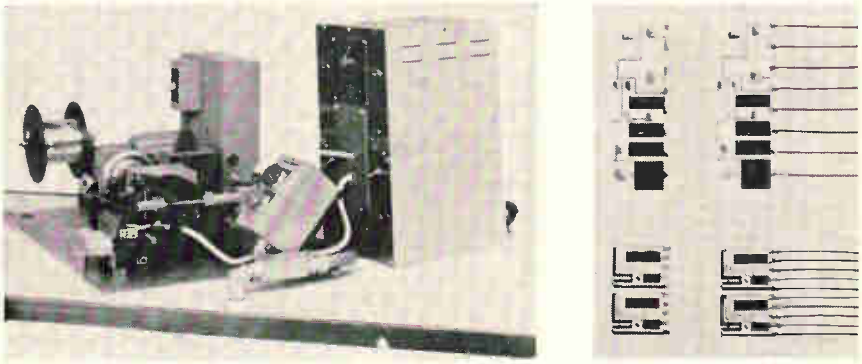
Varian Associates, 611 Hansen Way, Palo Alto, Calif. [421]

Rugged ferrite switch rated at 5 kw peak

The MA-3009A rugged ferrite switch, a 3-port device, is a nonreciprocal, coaxial circulator used as an spdt switch. Very high reliability is assured by the inherent ability of the ferrite material to withstand power overloads. Low, 85-mw holding power switches 4.2- to 4.4-Gc r-f at typical speeds of 1 msec from port 1 to port 2 or port 3. Insertion loss through connected ports is less than 0.4 db. Isolation at the third port is at least 20 db. Power rating is 5 kw peak and 10 w average. Weight for this compact unit is only 7.5 oz; dimensions are 1⅜ in. by 1½ in. by 2 in. Miniature TM connectors are supplied for r-f signals; solder lugs, for holding voltage. Present applications include antenna lobing and automatic system checkout, switching and transmission line isolation. Microwave Associates, Inc., Burlington, Mass. [422]



Lead soldering mechanized



Lead material is fed from spool at left to carriage and welding head. At right are typical microcircuits with soldered leads.

One byproduct of the swing to mechanized, high-volume production of hybrid mircrocircuits is a machine that welds or solders 10 leads to such circuits at a rate of 240 circuits an hour.

The machine, now being sold by the Federal Tool Engineering Co., can also be used to bond parallel leads to any conductive or nonconductive surface, including circuit boards and modules up to six inches long and one inch thick.

One person can operate two machines and produce 480 assemblies an hour, the company says. Loading and unloading are performed manually. Lead material—round or square wire or ribbon—is fed automatically from a spool to mechanisms that index the circuit or module under the welding head, cut the lead to length after it is bonded and raise and lower the welding head as each bond is made. The index plate, which determines the lead-spacing pattern, can be changed in less than one minute.

If the leads are to be soldered, rather than welded, the contact points on the circuit are pretinned.

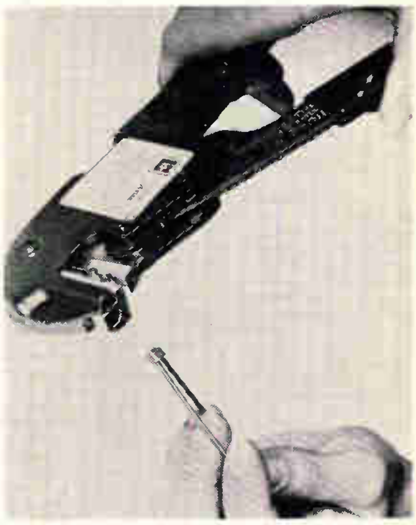
Specifications

Workpiece size	Up to 6 inches long and 12 inches thick
Lead spacing	0.040 to 1 inch, variable on same workpiece
Lead length	½ to 1⅝ inches
Heating time	0.3 msec to 1 second
Electrode pressure	1 to 25 pounds
Power supply	A-c, 1 kva; d-c, capacitor-discharge, 800 mfd
Price	$5,000
Delivery	12 weeks

The welding electrodes are used as resistance heaters. When the lead and the solder under it are heated, the solder reflows around the lead.

Federal Tool Engineering Co., 1384 Pompton Avenue, Cedar Grove, N.J. [451]

Thermocouple junction made by hand tool

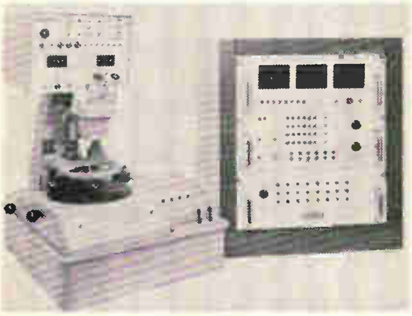


A simple hand tool can now do the same job as welding equipment in making thermocouple junctions. The procedure requires placing a metal collar, called a Quiktip connector, over the paired thermocouple wires, and pressing the collar with a forming tool to make the junction. Quiktip connectors come in various sizes to match 14, 20 and

24 Awg wires for iron-constantan, chromel-alumel, and copper-constantan. The price is $70 for the tool, and $12 to $18 per bottle of 100 connectors, depending on materials and size. Delivery is in 1 to 2 weeks. The connectors and tool are manufactured by the Thomas & Betts Co., and sold exclusively by Leeds & Northrup.

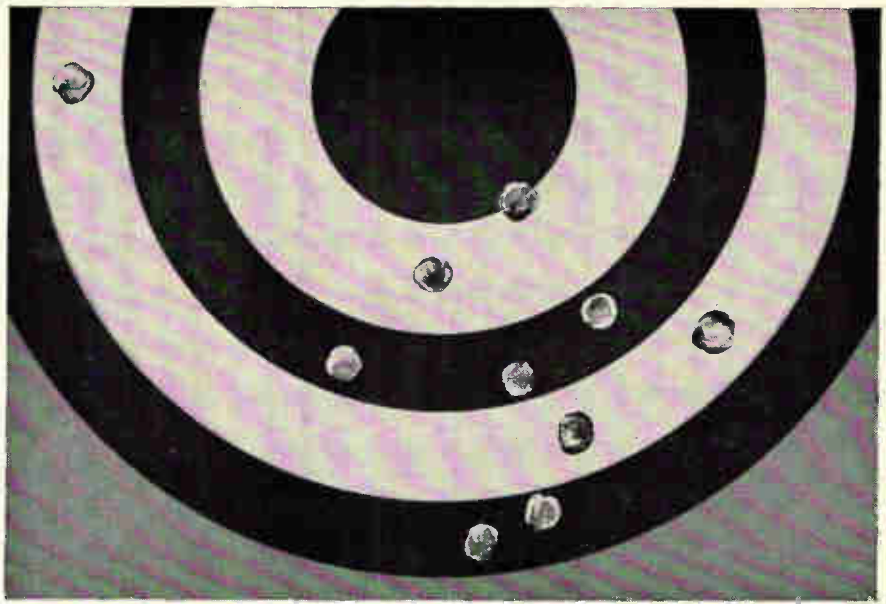
Leeds & Northrup Co., 4907 Stenton Ave., Philadelphia 44, Pa. [452]

Testing transistors in wafer form



The 920A automatic wafer die sort teams with the 1990-TT automatic go/no-go transistor tester to test and classify up to 75,000 transistors a day in wafer form. This eliminates costly wasted production time on reject units and classifies units before final assembly stages. Once the 920 probe points are positioned, the probe steps across, down, reverses its path and indexes until the wafer is completed. Each probing point is independently adjustable in X, Y and Z axes, has a variable probing pressure through the usable range of 7 to 17 grams, and has a usable range of 0.3 in. in each plane. X and Y axes are independently programable. The ring assembly accommodates any combination of probing heads and/or inking arms up to a combined total of 18. The transistor tester, with all solid state circuitry, tests up to 24 electrical parameters in any sequence, classifies into any of six categories, tests all d-c parameters, and can change parameter test limits. Test voltage range is 0.10 v to 100 v, current readout range is 1 nanoamp to 1.10 amps. The 1990-TT can also be used for final testing.

Electroglas, Inc., 150 Constitution Drive, Menlo Park, Calif., [453]



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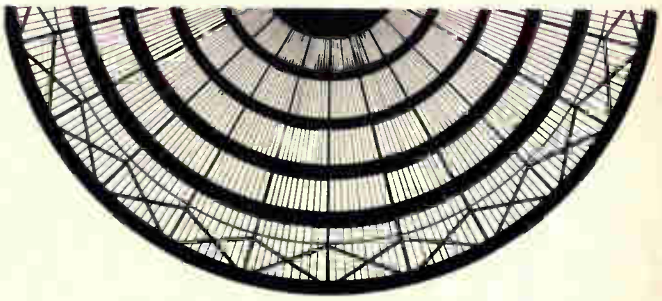

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New Books

Circuit design

Linear Analysis of Electronic Circuits
G.M. Glasford
Addison-Wesley Publishing Co.,
Reading, Mass., 580 pp., $15.

This book is intended primarily for the undergraduate electronics student. The circuit designer should also find it of some use because of the wide range of subjects covered. However, in many cases, the depth of the discussion will not be sufficient for the practicing engineer.

The book emphasizes electronic circuits using active devices and gives only very light treatment to the analysis of passive networks.

Both tube and transistor versions of various circuit functions are analyzed side-by-side in this book, a departure from the usual format of separate chapters for each. In the discussion of basic amplifier circuits, for example, the comparative design problems of tube and transistor circuits are easily observed because of the manner of presentation.

There is an analysis of idealized mathematical models of electron devices, including tubes, transistors, and vacuum and gas diodes. The field effect transistor is only touched upon.

The book covers all of the various forms of linear system analysis, such as time domain and frequency domain relationships, pole-zero analysis, methods of stability analysis, general two-port theory, including feedback, and signal flow graph analysis.

High-frequency model analysis is well done. This section includes a very useful discussion of peaking networks. One area which is neglected is the effect of lead inductance in high frequency transistor circuits, although the same subject is covered adequately for tube circuits.

The high-frequency power amplifier section implies that sizable amounts of power at hundreds of megacycles is essentially beyond the capabilities of transistors, which is no longer true.

John Tatum

Shockley Laboratories
ITT Semiconductors
Palo Alto, Calif.

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Technical Abstracts

Steerable antennas

Electronically steerable antennas for spacecraft-to-spacecraft communications
Dennis L. Backus
Grumman Aircraft Engineering Corp., Bethpage, N.Y.

Antenna systems that are electronically steerable show promise for future space missions. They permit a large number of beams to be steered independently. Gain and bandwidth can be increased to give better system performance without susceptibility to r-f interference. Antenna beams can be placed selectively to cover desired spatial areas.

Two types of antennas appear practical in that suitable components are available in the frequency range of one to 10 gigacycles. These types, the retrodirective antenna and the transdirective antenna, can be applied to spacecraft-to-spacecraft and Venus-spacecraft-earth communication links.

The retrodirective array works as an active device to reflect a signal back towards its source. In a variation called a retroredirective antenna, it receives energy from one direction at one frequency and retransmits it in another direction at a different frequency.

The transdirective antenna makes use of the properties of a Butler matrix array to form multiple beams at two separated frequencies. Similar arrays are utilized at each frequency; the elements of each are spaced at approximately half a wavelength.

Another promising design is an antenna with 16 elements in a cylindrical array about the spacecraft's spin axis. This antenna is particularly suited for spin-stabilized spacecraft.

Actual power in each channel can be low. A retrodirective array of 4,000 elements could have an effective radiated power of 400 kilowatts with only 100 milliwatts supplied at the output stage of each channel. A conventional parabolic reflector antenna of identical aperture must handle 400 watts to achieve the same ERP.

Weight of such arrays must be

reduced to less than 1/5 lb per channel to qualify for space systems.

Presented at the ION/AIAA National Space Navigation and Spacecraft Communication Meeting, Houston, Tex., April 30.

Long distance communications

Airborne experimental program for beyond-the-horizon microwave communications
Chester A. Hines,
Research and Technology Div.,
Wright-Patterson Air Force Base, Ohio

Passive reflectors and active satellite repeaters have been used to establish beyond-the-horizon microwave communications, but they require terminal equipment with low-noise receivers, high-gain antennas and high-powered transmitters.

In this paper, the author describes an experimental airborne system which could transmit beyond the horizon, via a satellite, as efficiently as with large ground terminals. The study proposes equipping a C-121C aircraft with a two-foot parabolic reflector antenna with a Cassegrain feed, a maser receiver cooled by liquid helium, and a transmitter capable of delivering 10 kilowatts of c-w power at X-band.

Because the microwave antenna has a relatively narrow beamwidth (5° x 5°) for an airborne antenna, a computer and servo-drive system are required to track the satellite and achieve maximum antenna gain. An error of only 2.5° will result in a loss of 3 decibels, related to the full antenna gain. The computer will use information from the aircraft's navigational sensors, and the orbital time or velocity vectors of the target, to provide signals for positioning the antenna.

The X-band receiver was designed for passive satellite communications in an earlier project called "Leap Frog." It comprises a maser amplifier, local oscillators, converts which provide a fixed intermediate frequency, and a demodulator with outputs for monitoring and recording signal data.

The proposed system test will involve the Syncom 3 satellite and other satellites now being planned.

Presented at Naecon, Dayton, Ohio, May 10-12

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Reliability Test Engineers—BS in EE, AE, ME, Physics or math with 4 years experience in Reliability to include test design and evaluation, test methods, research or stress test to failure programs. Must be familiar with all kinds of reliability test techniques and have demonstrated ability in evaluation and formulation of new test techniques or approaches from basic mathematics through laboratory procedures and ability to work closely with systems and design engineers under tight schedule conditions is essential.

Reliability Engineers—B.S. in Physics, EE, ME or AE with a minimum of 3 years experience in Advanced System Reliability Studies and proposals in addition to some practical design experience. Knowledge of the elements of good reliability programs and command of the state of the art reliability techniques is essential. Assignment will be heavy in conceptual stages of new Weapon and Aero-Space Systems where it is necessary to analyze Reliability and System effectiveness requirements and define the technical and management approaches. Background in statistics, probability, and operations research methods desirable.

Senior Support Systems Engineers—BSEE with 5-10 years experience in Electronic Support Systems for Military aircraft, missiles or spacecraft. Duties consist of design, development, and integration of complex electronic support equipment. Background in radar, servo mechanisms, analog/digital interfaces or digital computers essential.

Senior Circuit Design Engineers—BSEE with 5 to 10 years experience in solid state circuit design to military specifications. Experience with broad band amplifiers, A/D or D/A converters or high speed (10 mc) switching circuits desirable. Knowledge of packaging techniques for cordwood construction and integrated circuits helpful.

Digital Support Systems Engineers—BSEE with 3 to 5 years experience in military digital and data processing equipment. Must be capable of performing a comprehensive analysis of digital equipment to establish support concepts and define support requirements.

Logic & Switching Engineers—BSEE with 3 to 5 years experience in digital logic, timing & control, arithmetic elements and time sharing systems. Must be capable of developing a detailed logic design from system specification. Should be able to perform detailed system analysis to minimize hardware, eliminate hazards and timing problems and specify testing requirements.

Electronic Design Engineers—BS or equivalent with 5 to 10 years experience in checking, designing and drafting of Electronic and Electro-Mechanical devices. Must have a comprehensive knowledge of the latest Electrical and Electronic Packaging and Design techniques; thoroughly familiar with the application and selection of electrical components.

Electrical Power Systems Support Engineers—Graduate Engineers with a minimum of 4 years experience in one or both of the following: Aircraft & Space Vehicle, Electrical Power Systems, Support Equipment, Power & Control Circuits for Hydro-Mechanical Ground Support Equipment and Environmental Test Installations.

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New Literature

Semiconductor reliability. Fairchild Semiconductors, 313 Fairchild Drive, Mountain View, Calif., 94041. A 32-page brochure consists of a presentation that details steps in the manufacture of silicon semiconductor devices to assure their reliability.
Circle **461** on reader service card

Selector switches. Cherry Electrical Products Corp., P.O. Box CB465, Highland Park, Ill. A four-page brochure illustrates and describes a line of crossbar-type selector switches for programing, circuit design and testing, sequencing automatic equipment and other applications requiring rapid circuit selection. **[462]**

Choppers. James Electronics, Inc., 4050 N. Rockwell Ave., Chicago, Ill., 60618, offers catalog F-5186 covering a line of solid state photoelectric chopper/relays employing photo-resistive cells and associated light sources. **[463]**

Thermal switching relay. Metals & Controls Inc., a corporate division of Texas Instruments Inc., 34 Forest St., Attleboro, Mass. The Klixon 59000 series ambient compensated thermal switching relay is described in bulletin COMT-9. **[464]**

Ceramic capacitor chips. Gulton Industries, 212 Durham Ave., Metuchen, N.J., has published a bulletin on a new line of discrete capacitor chips for use in hybrid microcircuits. **[465]**

Standard wound coils. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass., 02138, has released a product news bulletin on standard wound coils with guaranteed volume dependability. **[466]**

Silicon h-v cartridges. Edal Industries, Inc., 4 Short Beach Road, East Haven 12, Conn., has issued a new bulletin describing the series L line of silicon high-voltage cartridges. **[467]**

Hall effect manual. Helipot Division of Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif., 92634, offers a 64-page technical manual on Hall effect. Included is a bibliography listing over 275 articles, papers and reports on Hall effect. **[468]**

Multiple-output, d-c power supplies. Dressen-Barnes Electronics Corp., 250 N. Vinedo Ave., Pasadena, Calif. Bulletin E-65 illustrates and describes various multiple-output, d-c power supplies, discusses how and when to specify them and gives application form for determining prices and delivery. **[469]**

Operational amplifiers. George A. Philbrick Researches, Inc., 22 Allied Drive at Route 128, Dedham, Mass., 02026, offers a 104-page book entitled "Generalized Instrumentation for Research and Teaching—a Primer in the Art of Using Operational Amplifiers in General Utility Instrumentation." For a free copy write on company letterthead.

Quartz crystals and filters. McCoy Electronics Co., Mt. Holly Springs, Pa., has published a catalog highlighting a complete line of both high and low frequency quartz crystals and filters. **[470]**

Coaxial relays. Magnecraft Electric Co., 5565 N. Lynch, Chicago, Ill., 60630. Bulletin No. 465 on coaxial relays describes a wide selection of r-f switching relays, including varied mounting arrangements, integrated with an extensive choice of proven relay structures. **[471]**

Phase-to-voltage converter. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif., offers a bulletin on the model 791 solid state, silicon, phase-to-voltage converter. **[472]**

Resistor catalog. RCL Electronics, Inc., One Hixson Place, Maplewood, N.J., announces availability of an expaneded engineering catalog of precision wire-wound resistors, power resistors and networks. **[473]**

Capacitance bridge. Boonton Electronics Corp., Route 287, Parsippany, N.J., 07054. A four-page technical data bulletin discusses the model 74D, a 100-kc capacitance bridge. **[474]**

Transmitters and frequency sources. Sanders Associates, Inc., 95 Canal St., Nashua, N.H., has issued a six-page bulletin covering a new line of solid state transmitters and frequency sources for uhf and microwave applications. **[475]**

Digital display system. Farrand Controls, Inc., 99 Wall St., Valhalla, N.Y., 10595, offers a brochure describing a numerical control digital display system for machine tools. **[476]**

Soldered connections. Alpha Metals, Inc., 56 Water St., Jersey City, N.J., 07304, has available an illustrated technical bulletin on the proper soldering techniques for assuring economical, reliable soldered connections. **[477]**

Metal film resistors. Jeffers Electronics Division, Speer Carbon Co., DuBois, Pa., 15801. A 10-page handbook describes the manufacture and quality control of ultraprecise JXP metal film resistors, restricted to characteristic E of MIL-R-10509. The handbook may be obtained by request, giving full title on letterhead.

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June 28, 1965

Electronics Abroad

Volume 38
Number 13

France

Paris Air Show

Late in May, an American reporter in Moscow asked 76-year-old Soviet designer Andrei N. Tupelov about rumors that he was working on a supersonic transport. Tupelov replied that he had never heard of such a project in Russia.

Three weeks later the world heard of it. At the Paris Air Show, a plastic scale model was shown of the proposed 1,500-mile-an-hour plane, designated the TU-144 for its designer, Andrei N. Tupelov.

Crude instruments. It was one of three aeronautical spectaculars that the Russians showed in Paris. The other two were flown there: a turbojet transport that can seat 720 passengers, and a helicopter that can lift 25 tons.

The aircraft impressed visitors to the show, but their avionics equipment seemed crude by Western standards. A British electronics engineer, in the cockpit of the turbojet transport, said, "The instruments look heavy and clumsy." After examining the helicopter's instrument panel, a United States engineer called it "strictly World War II stuff."

Mach 2. The Soviet SST seems designed to compete with the British-French Concorde, whose prototype is scheduled to fly in 1968. The Soviet newspaper, Izvestia, said the TU-144 would be ready when the Concorde is.

The Russian plane will be about as large and as fast as the Concorde, but much smaller and slower than a proposed United States SST that isn't expected to fly until well into the 1970s. Soviet officials say the plane will have a three-man crew and that all navigational equipment will be automatic.

Comparison. All three SST's would have a range of about 4,000 miles. Here's how they would compare in other respects:

Cruising speed: Soviet, 1,550 miles an hour; British-French, 1,450; U. S., 2,000.

Payload: Soviet, 121 passengers; British-French, 130; U. S., 200.

Coming down. While Westerners were examining the Soviet aircraft, the Russians were shopping for automatic landing equipment. A Soviet navigator said that for landing in bad weather, Russian planes require 3,280 feet of visibility forward and 263 feet vertical. U. S. commercial airliners are now permitted to land with only 200 feet of vertical visibility and 2,600 feet horizontal. With automatic landing, these distances would be reduced to 100 feet vertical and 1,200 feet horizontal.

On the day before the opening of the Paris show, a British jetliner carrying 88 passengers touched down in London, using a dual-track automatic landing system made by S. Smith and Sons, Ltd., of England. The landing, the first such computer-controlled operation involving passengers, attracted attention to the Smith exhibit in Paris.

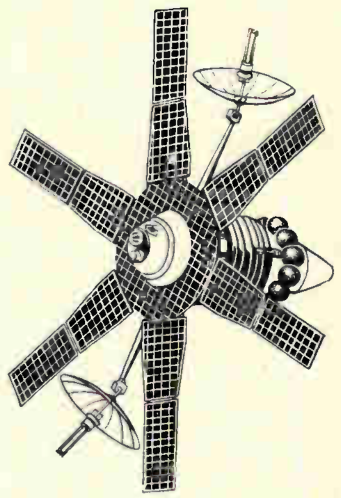
Elliott-Automation, Ltd., of Britain has a contract to supply an automatic pilot system for the Concorde. The Concorde system is expected to be fully automatic.

A French company, Telecommunications Radioelectriques et Telephoniques (TRT), displayed the radioaltimeter it will provide for the Concorde.

Soviet Union

Little light on Lightning

Apparently finding no big Lightning bugs, Soviet scientists made much this month of the release of a sketch and some information about their communication satellite, Lightning 1, which was launched late in April. The sketch was new, but the data wasn't.



Lightning 1 is Soviet version of Early Bird. Bulblike objects on cylinder are small jets to correct orientation. Coils around cylinder are for cooling by radiation.

The satellite is cylindrical, with a conical end. Like the United States' Telstar and Early Bird, it is powered by solar batteries that operate through a system of voltage regulators. The batteries are in the six "windmill" panels that unfolded after Lightning attained its highly elliptical orbit.

Few specifics. The Russians said ground stations can be small because Lightning's antennas have a very narrow beam angle. They did not disclose the beam angle, nor the size of the ground antennas; neither would they specify the frequencies at which the satellite operates.

Lightning has relayed a color-tv signal from Moscow to a station described as being "several thousand kilometers away." The Russians did not describe the system they used, but it wasn't the French Secam nor the American NTSC. They did say, however, that Lightning can relay any kind of color-tv signal.

Uruguay

Life before birth

Every year, dozens of prominent physicians and physiologists from every part of the globe travel to the University of the Republic in Montevideo (enrollment 11,500) and head directly for the Faculty of Medicine, which has become an international center for the study of pregnancy and childbirth.

They are attracted by work done at the school's Obstetrical Physiology Service, whose electronics laboratory is considered by many to be the best-equipped in the medical field.

Grants galore. Chairman of the obstetrical service is Prof. Roberto Caldeyro-Barcia, an electronics-oriented physician who has obtained grants totaling $600,000 in the past 11 years from such United States institutions as the Rockefeller Foundation, National Institutes of Health and the Josiah Macy Jr. Foundation.

The electronics lab is headed by Jorge Pantle, who taught himself electronics and is, at age 36, a veteran of 15 years in the young field of biomedical instrumentation. Pantle holds a U.S. patent on a system that distinguishes the fetal heart's electrical signals from those from the mother's heart; the method employs electrodes on the mother's abdomen.

International standards. Perhaps the institute's outstanding achievement was the development in 1961 of a method for measuring several physiological functions within the uterus. This method, and the measurement units that were tailored to it, have become international standards, enabling laboratories in one country to compare their findings with those in other nations.

Few of the institute's instruments are entirely new; they use standard pressure transducers, cardiotachometers, and other devices long known in medical electronics. What impresses medical specialists, however, is the scope of the research done in Montevideo and the availability of so many modern electronic instruments—more than

Roberto Caldeyro-Barcia: physician with a bent for electronics

$100,000 worth—in one place. There are instruments for measuring dozens of variables during every stage of pregnancy to provide precise information about fetal heartbeat, pressure in the fluid that surrounds the unborn baby, and the energy output of the uterus at various stages of pregnancy up to the moment of delivery.

The institute's physicians and physiologists attend electronics courses conducted by Pantle. These serve a dual purpose: they help the doctors learn what electronics can do for them, and they help Pantle and his staff find out what the doctors need.

The Netherlands

Page One

Strange music is coming from f-m radio receivers in Belgium and the Netherlands. At 87 megacycles, listeners receive beeps in a seemingly random series of 34 tone frequencies between 1,010 and 6,500 cycles per second.

The tones are coded signals, relaying messages for subscribers to an f-m paging system that's already in operation in the Netherlands and is scheduled to start early next year in Belgium. The system, called Semaphone, was developed by Philips Gloeilampenfabrieken, N.V., of the Netherlands.

Companion. Each subscriber is given an 11-pound f-m receiver that can accompany him anywhere—in a car, on a boat, at a football match. The receiver contains a decoder that is tuned to respond only to the user's private three-tone calling signal. Three lamps on the face of the receiver are lighted up in any of six combinations, representing six predetermined messages.

From any telephone in the country, a caller can contact any subscriber. He simply dials the number of the Semaphone exchange, then the individual call numbers, and finally the number that signifies one of the six messages.

At the receiver, a buzzer informs the subscriber he is being paged. He looks at the lamp display and quickly gets the message. For example, a Dutch doctor making his rounds might leave a variety of codes with his nurse: one would mean "call the office," another "stop at hospital A," a third "call your home," and so on.

Computer control. At present, Semaphone calls are broadcast from two transmitters in Holland; next year the Belgian Telephone Administration will add two more transmitters, one near Brussels and the other near Liege.

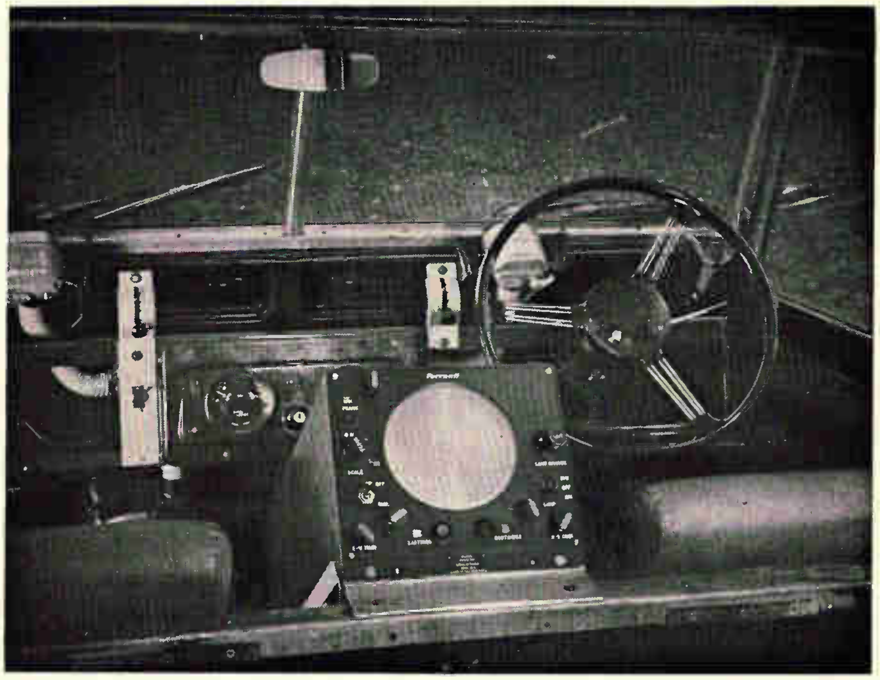
Calls from both countries will be routed through a computer at the Hague. The computer, now in operation for the Dutch system, transforms telephone-dial pulses into tone frequencies. Its memory temporarily stores digital information for each call so that it can be broadcast again 15 seconds later.

Permutations. The frequency band from 87 to 87.5 megacycles will be divided into four channels 50 kilocycles wide; at any instant, each transmitter will be on a different frequency, so that every call will be broadcast from each transmitter in sequence. The calling tones will ride in one of these 50-kc channels, so that each receiver will respond only to its own distinctive call signal—a permutation of three of the 34 tone frequencies broadcast on each channel.

This permutation permits each channel to handle 25,000 call numbers. Inside the decoder, four tone detectors respond in sequence to the calling tones. The fourth detector closes a circuit; this activates the buzzer and switches the indicator circuit to the code-tone detector.

The price. About 1,100 Netherlanders have subscribed since the system went on the air late in September. The Belgian Telephone Administration says it should have 1,500 subscribers in that country.

Subscribers in Belgium are expected to pay about $14 a month for the service, compared with about $12 in the Netherlands. Callers pay about five cents to dial each message.



Navigator nestles beside driver's seat.

Great Britain

Motorist's navigator

One of James Bond's least glamorour driving companions is a computerized navigation system that keeps him on the trail of Goldfinger. The movie may be fictional, but the automobile navigator is very real; it's now being tested by the British army.

The system was developed by Ferranti, Ltd., as part of the navigation system for the proposed TSR-2 supersonic fighter. The plane has since been abandoned, but Ferranti expects its navigator to find many uses—in military and airport vehicles that must operate in dark and fog, in auto events such as the Alpine Rally in France next month, and ultimately in passenger cars.

Maps on film. In the Ferranti navigator, ordinary road maps with grid lines superimposed are photographed on 35-millimeter film, one map to a frame. A light source projects the map onto a five-inch display screen beside the driver. A ring marker on the display gives the vehicle's position, correct to within 300 feet regardless of how far the vehicle has traveled, and a heading marker shows direction.

The display is mounted on a control panel; the entire unit is 16 by 9 by 8 inches. Two ring servos move the map, either horizontally for east-west travel or vertically for north-south changes.

Flux detectors. Data for the display comes from a land navigation system developed by the British government and produced by the Sperry Gyroscope Co. of London, a unit of the Sperry Rand Corp. The Sperry system uses two magnetic flux detectors that act as compasses to find the vehicle's position. Ordinary magnetic compasses cannot be used because of deviations caused by magnetic material in the vehicle.

The flux detectors, on a boom extending three feet behind the vehicle, are spaced in such a way that the vehicle's magnetic effect at the nearest detector is twice as great as at the farthest detector. A small computer first subtracts half the output of the nearest detector from the full output of the farthest detector; this cancels the signal produced by the vehicle's magnetic effect. From the remaining signal, corresponding to one-half of the earth's magnetic flux, the computer determines the vehicle's bearing.

The distance traveled is picked off the odometer. The computer performs a dead reckoning by continuously resolving the distance and bearing into X and Y references on the map and counting the changes.

At present, a map display system costs about $6,500, but Ferranti figures mass production can cut the price to $2,000 each for large orders.

IC logic

The first European process-control computer using silicon integrated-circuit logic has been designed by Ferranti, Ltd., of Manchester. The machine, the Argus 400, is less than one cubic foot in size.

Employing single-chip circuits mounted in TO-5 cans, the computer has add-subtract times of 12 microseconds, and memory of 4,096 words of 24 bits.

The central processor uses fewer than 600 elements of 14 different types of these new circuits; other Ferranti processors use more than 1,000 elements.

Six-layer boards. The logic units are mounted on six-layer printed circuits boards that are connected by wrapped joints. The core unit uses matrix stacks with cycle times of two microseconds. Their 0.030-inch cores are mounted on six circuit panels, four bits to a panel.

Special input-output units provide for operation of a lamp and a printer, selection of analog or digital inputs, and generation of analog outputs to drive a cathode-ray tube. Up to 4,000 input-output channels can be directly addressed. A system for direct digital control is also available using a direct-access store.

Japan

The absentee

Six of Japan's seven computer companies showed their wares June 14 to 19 at the Harumi Fair Grounds in Tokyo, but much of the interest centered on the missing manufacturer, IBM Japan, Ltd., a subsidiary of the International Business Machines Corp.

IBM is Japan's biggest producer of digital computers, in terms of gross sales, and her only exporter. The company will introduce models 20 and 40 of its System 360 late next year. The six exhibitors apparently hoped to beat IBM to the punch; their emphasis at the show was on machines now in production.

In New York, officials said IBM stayed out of the show because it's planning its own exhibition "in the next few weeks" in Tokyo.

Honeywell design. The Nippon Electric Co. showed its NEAC 2200 series, which relies heavily on technology obtained from Honeywell, Inc., under a licensing agreement. The new model 200 corresponds somewhat to the Honeywell H-200; other models veer further from their Honeywell counterparts. Most machines in the 2200 family have 10-month delivery schedules.

Nippon Electric rounded out its line with a larger computer, the model 500, whose design is completely original and has about the same capacity as IBM's 360-65. It is the first Japanese computer to use integrated circuits and the first to use memory planes consisting of layers of magnetic wire sandwiched between layers of copper wire. With simulation software, the 500 can use IBM programs.

Minicomputer. At the other end of the scale, Nippon Electric showed 11 versions of its NEAC 1210 computer, the smallest computer made in Japan, with a memory of 500 six-digit words.

Fujitsu, Ltd., the only Japanese company that designs its own computers entirely, showed its new Fontac Series 230, which includes improvements on earlier models.

Hitachi, Ltd., emphasized existing models, rather than new machines. However, the company is working on a new family of computers based on the Radio Corp. of America's Spectra 70.

Other companies exhibiting were the Tokyo Shibaura Electric Co. (Toshiba), Oki Electric Industry Co. and Mitsubishi Electric Corp.

Canada

Decision on color tv

Color television, the most successful segment of United States commercial electronics, is coming to Canada in a year and a half. This decision, announced June 15 before the House of Commons, ended a controversy between Canadian companies that had urged the action and the publicly-owned, government-financed Canadian Broadcasting Corp. which favored a more gradual approach.

Secretary of State Maurice Lamontague said broadcasters may apply immediately for licenses to broadcast in color starting Jan. 1, 1967. The CBC, he added, will begin national telecasts April 15, 1967, from a $10-million studio at the Montreal World's Fair.

All 50 stations affiliated with the CBC will be able to carry programs from Montreal, but may not be able to originate their own color programs; that would require a policy decision, and large appropriations, by Parliament.

Head start. Color tv is not entirely new in Canada. Receivers already are owned by about 10,000 families who live within broadcast range of U.S. stations. To electronics companies, this was convincing evidence that Canadians were ready for color tv and reason enough for the government to lift its ban on broadcasts. At least six companies are already assembling color receivers in Canada, and RCA Victor, Ltd., an affiliate of the Radio Corp. of America, is manufacturing color tubes.

The CBC, however, interpreted the statistics differently, noting that about one-half of Canada's five million homes are within range of U. S. stations.

Another factor in the CBC's attitude may be the schism between English- and French-speaking sections of the bilingual country. Tapes of English-language telecasts in color are easy to obtain from the U. S., but programs in French would have to be produced by the CBC.

Dollar impact. The Electronic Industries Association of Canada estimates that the introduction of color tv will provide $31.5 million in salaries and wages, create 7,000 jobs, and require the purchase of $30 million worth of electronic equipment in the first year.

The association predicts annual color-tv sales of $60 million.

Around the world

France. The International Telephone and Telegraph Corp. has taken over leadership of a consortium bidding on Nadge, an air-defense ground-environment system for the North Atlantic Treaty Organization. The group had been headed by Litton Industries, Inc. There are two other bidding groups, one headed by the Hughes Aircraft Corp., the other by the Westinghouse Electric Co.

Hong Kong. This crown colony, where schools still teach children how to work an abacus, will soon have a commercial electronic data-processing center equipped with a model 315 computer made by the National Cash Register Co.

Mariner IV looks at Mars thru a GEC vidicon . . .

The GEC 1343-010 Vidicon will be used to pick up approximately 22 pictures of the Mars surface during the 30-minute fly-by planned for mid-July, 1965. The tube will be exposed once for 200 milliseconds every 48 seconds, and the image stored on the storage surface of the tube will be read out over a period of 24 seconds without any loss of detail. The GEC 1343-010 Vidicon will operate over a temperature range from −40°C to +50°C. Developed especially for Mariner, GEC's 1343-010 is quite a vidicon!

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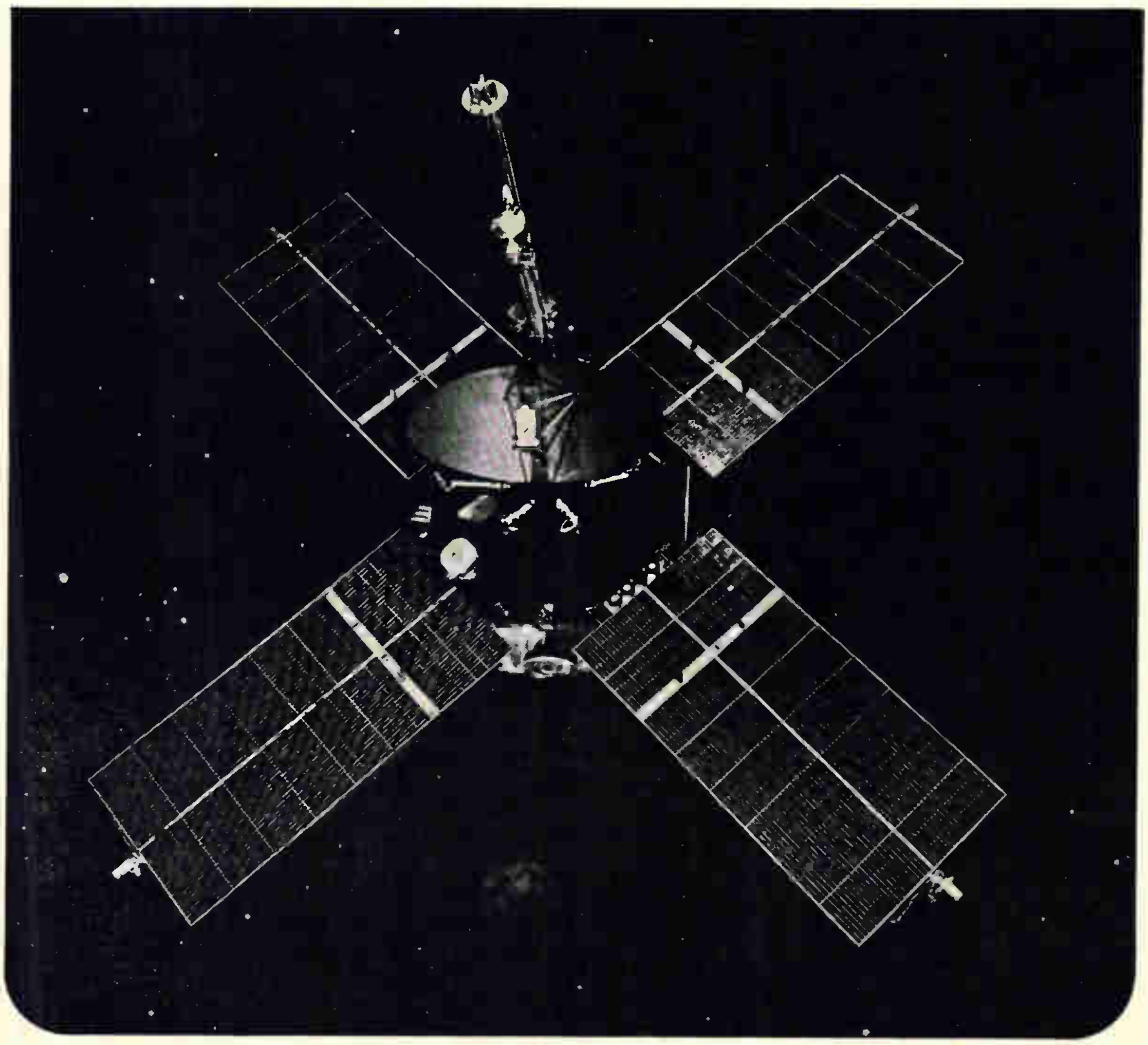

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